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McGraw-Hill Publishing Company, Inc. September 10, 1936 Twenty-five Cents, Five Dollars per Year

Three asphalt pavers, working in tandem and covering full street width, resurface two blocks a day in Evanston, Ill.

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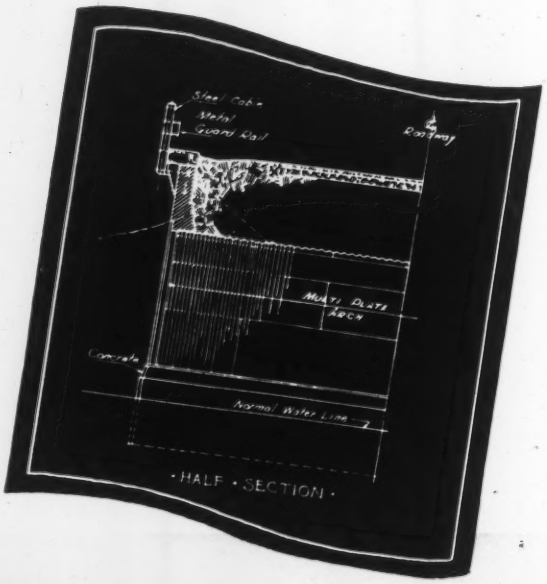

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More about maps

WHAT this page had to say a few weeks ago on the subject of maps and their increasing use evidently struck a responsive chord with a number of readers.

One of them writes to point out that air travel also is helping to popularize the understanding and use of maps: he takes occasion to suggest a line of possible improvement in maps available to the air traveler. It is evident, of course, that the map furnished to the air passenger does not stand on the same footing as does the road map of the motorist. The air pilot has access to airway maps of comparable scope. But the map in the hands of the air traveler is rather a device for enhancing the interest and pleasure of air travel.

Bearing this in mind, the comment of this correspondent is to the point and well worth recording for the information of map makers and the operators of the air lines. He says:

"Maps for the air traveler are in the same state of development as the road map was ten years or more ago. An air map should look like territory when seen from the air. The requirement of the air map is very different to that of a map used to guide one over the surface. Why can't the air lines give you a map which will enable you to locate yourself at any time by merely picking out a characteristic landmark and referring to your map? As it now stands, it is necessary to note your take-off time, calculate ground speed and then do some guessing in order to find out whether the town below you is Goshen or Conshohocken."

Another correspondent reacts on an entirely different plane. He concedes the development as pictured by this writer but he deplores the necessity for appealing to a popular interest in order to generate support for the fundamental map making activities of the government.

He reminds us that too often engineers are tempted to project major engineering undertakings without the essential data that might be made available by adequate and authoritative basic maps. He speaks of the risks to both life and property incurred when such works are planned with insufficient data and he implies the waste that may be involved in the unnecessary duplication of mapping for explorations and studies because of a lack of adequate basic maps. He concludes by asking:

"Is not this almost altogether the engineer's problem? And if he insists that he have satisfactory maps on which to make his plans will he not, if he is in earnest, finally get them?"

The need for insistent and consistent support by the engineering profession for the mapping activities of the government admits of no question. So slow has been the progress of mapping the nation that even now, with but a fraction of its area actually mapped, a large part of the work already done has become obsolete. Through its organized groups the profession has worked for years to correct this situation with more or less effect on progress. It is assumed that these efforts will be continued.

But meanwhile, added strength can be derived from the popular understanding and support fostered by the widest possible use of maps by the man in the street. Such reinforcement should be welcomed by those who are most concerned with the more fundamental and technical values.

Willard Chevalier

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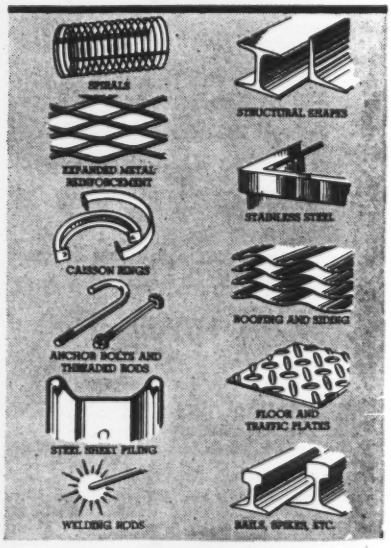

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Typhoid and Water— Typhoid control centers largely on pure water. Next week, M. N. Baker analyzes the graphic decline of typhoid during the last 30 years as close attention was focused on water supplies. Members of the New England Water Works Association, meeting in New York City on Sept. 22-25, have played an important part in placing their section of the country in the group with the lowest death rate from typhoid.

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ENGINEERING NEWS-RECORD

September 10, 1936

Evanston Review Photo

EVANSTON'S STREETS being resurfaced with three ribbons of asphalt laid simultaneously by triple-unit paving plant.

Three Asphalt Pavers in Tandem

Evanston streets resurfaced with hot asphaltic concrete in rapid time by triple-unit plant that completes two blocks daily

CITIZENS of Evanston, Ill., voted a $200,000 bond issue last fall as the city's share of a PWA project for resurfacing 35 miles of old water-bound macadam streets, and then resigned themselves to a year of torn-up thoroughfares and troublesome detours. However, their misgivings turned to surprise and then to enthusiastic delight when the contractor moved in with an ingenious arrangement of three asphalt pavers set in tandem, to cover the entire width of street, and proceeded through town at the rate of two blocks per day. A block is never closed off for more than 24 hr., and usually for 12 hr. or less.

Fast progress

The project, aggregating 475,000 sq.yd. of pavement, was divided into five sections, all of which went to one contractor. Contracts were let last December, and completion date was stipulated as Dec. 15, 1936. Inclement weather delayed start of principal work until late in May, but the whole project will be completed early this month, three months ahead of schedule.

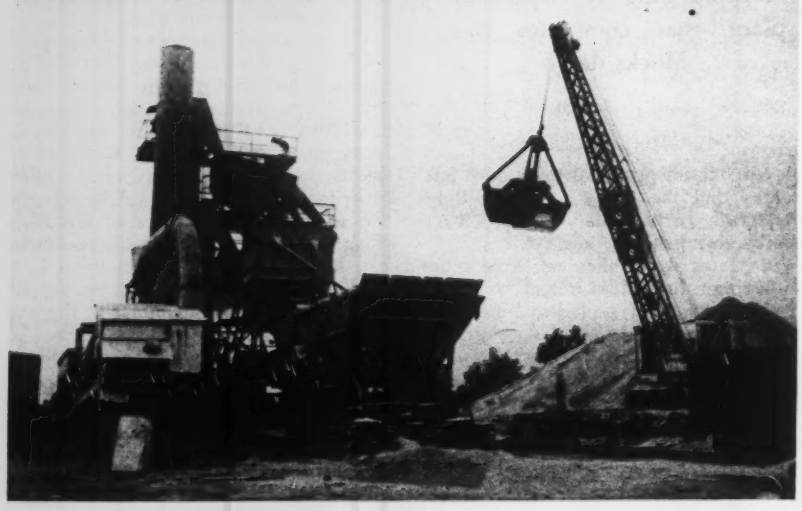
Alternates were taken on three types of paving: hot plant-mixed asphaltic concrete; modified asphaltic limestone; and a road mix surface of open graded aggregates with a cut-back asphalt binder. The first two types were specified as 2 in. thick on primary and 1½ in. thick on secondary streets, while the road mix was to be 2¾ in. and 2 in. thick, respectively. The entire project was let for the first type at unit bid prices of 74c. for the 2-in. surface and 64c. for the 1½-in. thickness, including preparation of the base. At additional prices, considerable curb, gutter and manhole work was included.

The principal pavement laying plant consists of three self-propelled asphalt pavers, serviced by eight 10-ton dump trucks. The pavers are each adjustable in width from 8 ft. to 12 ft., and can be arranged to cover the full width of all streets, which vary from 24 ft. to 36 ft. between curbs. Most of the streets under repair are water-bound macadam of ancient age, averaging 37 years old. The only preparation given them is to level off the low spots with an asphalt binder and to raise manholes to the new pavement grade.

Arrangement of pavers

At the start of a new block the first paver is set close to the left curb. A waiting truck of hot asphalt mix backs up to the machine, and as the two move slowly forward the truck driver hoists the dump body to keep the paver hopper

full. The paver spreads, screeds, tamps and rolls the mix to uniform thickness and to a smooth surface all in one operation. Close behind the first machine comes the second paver covering the center strip of roadway, kept just far enough back to permit maneuvering of the trucks. Shortly after the second paver is under way, the third machine follows, hugging the right curb. As the pavers follow close to each other, the full width of street is covered before the mix cools off, consequently there are no longitudinal joints.



THREE ASPHALT PAVERS cover entire width of street in one operation (above). The machines are charged by dump trucks hauling 10-ton loads of hot mix. Below is a view of the 1,000-ton daily capacity asphalt plant.

Small labor crew

Except for the equipment operators, the entire labor crew consists of only 24 men, in contrast to the 24 to 27 usually required for each crew under hand raking methods. The relief officials entered no protest on the use of machine pavers, for asphalt rakers are scarce in the Chicago territory. Very little hand raking is necessary behind the pavers, and hand tamping is limited to areas around manholes, along curbs and in driveway entrances. The crews work two 6-hr. shifts daily, five days a week. Daily progress ranges from 9,000 to 11,000 sq.yd. Often a block is cleaned up in less than half a day.

Following behind the pavers is a fleet of rollers that thoroughly compact the pavement. The fleet consists of two 15-ton rollers with three wheels each, and one 8-ton and one 10-ton tandem rigs for cross rolling. Prior to final rolling the surface is covered with a thin layer of limestone dust.

Central mixing plant

At the western limits of the city the contractor has installed a complete asphalt plant of the latest type that turns out from 900 to 1,000 tons of mixed material daily. Four aggregates are used: $\frac{5}{8}$-in. crushed rock, torpedo sand, fine lake sand and limestone dust filler. The sand and stone, received by rail, are unloaded into stockpiles or directly into a three-compartment bin by a crane. Leading from the bin to a long rotary dryer is a chain bucket conveyor, loaded by mechanical feeders that roughly proportion the aggregates. The dryer, fired by a forced-draft oil burner, is equipped with an exhaust fan that, in combination with a cone separator, traps all rock dust, which is conducted to the filler batcher bin. Aggregates are heated to a temperature of 400 deg. in the dryer.

The hot sand and stone are lifted by bucket elevator to the top of the plant, and then flow through separating screens to weighing batchers. Stone dust filler, received in bags, is also conducted by bucket elevator and screw conveyor to the batchers. Aggregates, filler and asphalt are weighed consecutively into a 2-ton capacity mixer. Materials are mixed dry for 25 sec., then the hot asphalt is added and the wet mixture is churned for another 25 sec. Discharge of a batch into a truck takes 16 sec., and each truck receives five batches, or 10 tons of material. The asphalt mix leaves the plant at a temperature of 335 deg., and arrives at the job under canvas with a loss of only 25 deg. in temperature. The average

haul from the plant to the job is 2 miles.

About one tank car of asphalt is used daily. Storage capacity for three cars is available to guard against delays in delivery. Two large portable steam boilers supply heat for unloading the cars and for the storage tanks.

Specifications and tests

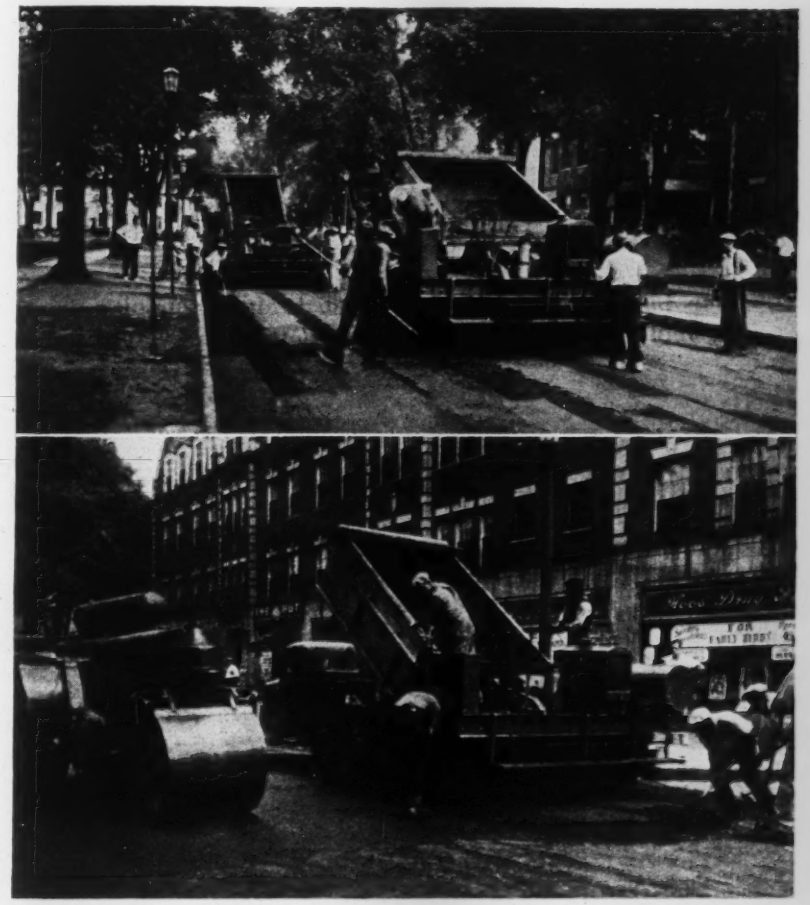
The specifications call for the following proportions of materials: bitumen, 5 to 7.5 per cent; mineral passing 200 mesh screen, 8 to 15 per cent; 80 mesh, 6 to 15 per cent; 40 mesh, 10 to 20 per cent; 10 mesh, 10 to 20 per cent; ⅜-in. screen, 15 to 30 per cent; ⅝-in. screen, 5 to 20 per cent; and ¾-in. screen, 0 to 15 per cent. At least 60 per cent by weight of the filler must pass a 325 mesh screen, and at least 80 per cent must pass a 200 mesh. Coarse aggregate (above ⅜ in.) must comprise from 40 to 50 per cent of the entire mix. The usual specifications apply for hauling, laying and rolling. The finished surface must have a smoothness of not more than ¼ in. variation in 10 ft. longitudinally.

A pavement of high density is being obtained. Tests show that the specific gravity of the compressed pavement is 98.5 per cent of theoretical maximum. Shearing strength at 140 deg. is 36.2 lb. per sq.in. by the Chicago testing method, which corresponds to 1,600 lb. on the Hubbard-Field scale.

Paid by local vehicle tax

Evanston, in common with most Illinois cities, has a local motor vehicle tax. The $200,000 bond issue will be retired in five years by this tax.

George W. Craig, commisioner of public works and city engineer, and J. W. Cleveland, assistant city engineer, are in charge of the work for the town. The contract for all five sections is held by the Arcole Construction Co., of Chicago. John Kearney is superintendent.



THE PAVERS in action are shown by these close-up views. Note the small number of men required for each crew, about one-third of those found on usual asphalt paving work.

Water Power in the United States

THE United States would have 57,184,000 hp. of hydro-electric power available 50 per cent of the time if all streams were fully regulated and all possible power plant sites occupied by plants having an over-all efficiency of 70 per cent, the Geological Survey estimates.

Similar estimates of the potential water power in the U. S. have been published by the Geological Survey since 1908, the last preceding estimates having been released in 1935. In order to conform to tentative international standards, the present survey also shows the potential water power in kilowatts at 100 per cent efficiency, based on water available 95 and 50 per cent of the time and on the arithmetical mean flow, without taking account of future storage.

These figures for potential power are not directly comparable with figures for developed power, because developed power is customarily reported in terms of the capacity of the installed water wheels or turbines, which usually is several times the potential power available 95 per cent of the time. Probably with complete development of the water power of the whole country the installed capacity of water wheels and turbines would amount to 80,000,000 hp. or more.

POTENTIAL WATER POWER IN U. S.
(All possible storage; 70 per cent efficiency)
thousands of H.P.

State and division	Available 90 percent of the time		Available 50 percent of the time	
	Horsepower	Percent	Horsepower	Percent
United States	42,753	100.00	57,184	100.00
New England	988	2.31	1,641	2.87
Middle Atlantic	4,895	11.45	6,242	10.92
East North Central	869	2.03	1,640	2.87
West North Central	1,172	2.74	1,884	3.29
South Atlantic	2,936	6.87	4,058	7.10
East South Central	2,620	6.13	3,761	6.58
West South Central	764	1.79	967	1.69
Mountain	10,775	25.20	13,031	22.79
Pacific	17,734	41.48	23,960	41.90

POTENTIAL WATER POWER IN U. S.
(Existing flow; 100 per cent efficiency)
thousands of kilowatts

Division	Available 95 percent of the time	Available 50 percent of the time	Based on mean flow
United States	25,045	53,863	82,180
New England	672	1,686	2,441
Middle Atlantic	3,727	6,250	7,555
East North Central	756	1,712	2,595
West North Central	851	1,838	2,817
South Atlantic	1,415	3,859	5,715
East South Central	911	3,612	5,418
West South Central	172	471	1,302
Mountain	5,721	10,807	18,898
Pacific	10,820	23,628	35,439

Long Continuous Truss Bridge Spans Mississippi River

New public toll structure at Hannibal, Mo., containing two-span, 1,125-ft. continuous truss, replaces a circuitous highway route that involved use of a narrow railroad bridge

By John I. Parcel

Sverdrup & Parcel, consulting engineers, St. Louis, Mo.

THE HIGHWAY TOLL bridge recently completed over the Mississippi River at Hannibal, Mo., provides a much improved crossing for U. S. Highway 36, one of the most heavily traveled east-west routes. Prior to the construction of the bridge, whose principal feature is a 1,125-ft. continuous truss of two spans, the traffic was carried over the single-track railway bridge of the Wabash Railroad built in 1876 and located about a mile north of the Hannibal business district. The approach highway on this old route was forced to make a right angle turn at the west entrance to the bridge where it crosses the C.B.&Q. and Wabash tracks at grade. Traffic from the latter railway is discharged from a tunnel whose portal is only 30 ft. from the bridge entrance. This arrangement created a dangerous traffic situation, and in addition the route from the bridge through the city was such as to make safe and rapid movement of traffic very difficult.

FIG. 1—SPANNING from Hannibal, Mo., into Illinois this new bridge replaces highway facilities on the old railroad bridge upstream. The two-span continuous truss is 1,125 ft. long, the through-trusses at either end 300 ft. long.

The new bridge is much more favorably located and will provide, it is believed, ample facilities for the normal traffic using the route. The main structure consists of a two-span through continuous truss 1,125 ft long, flanked on either side by a simple through truss span of 300 ft. The approach structure on the Illinois side consists of two simple deck truss spans of 175 ft., two of 80 ft., and six 50-ft. girder beam spans, landing on a long approach fill. The Missouri approach consists of two 38-ft. girder beam spans landing on a 96 ft. fill and retaining wall. The concrete slab roadway is 22 ft. inside curbs. No regular sidewalk is provided, but the wide curb tops (1 ft. 4 in.) are believed to provide adequate facilites for such pedestrian traffic as will use the bridge. The trusses are 27½ ft on center.

City, state and federal cooperation

The bridge was built by the city of Hannibal through a PWA loan and grant supplemented by a grant of $200,000 from the Missouri state highway department. The financial set-up contemplates amortization in twenty years. The necessary interest and sinking fund payments constitute a first charge against the structure; the city of Hannibal guarantees the cost of operation unless and until the income over and above interest and amortization is sufficient to cover this item. All income in excess of interest and operation charges must go toward amortization. It is expected that the state highway departments of Missouri and Illinois will take over the maintenance and operation of the bridge when the PWA loan is retired and the bridge becomes free.

The substructure design involved no unusual features. For the sake of appearance an open web was used and the piers designed as rigid frames.

The layout of the main structure was largely controlled by the War Department requirement of two channel spans each with a clear opening of 550 ft. and a vertical clearance of 55 ft. (Spans 4 and 5). The flanking spans (3 and 6) were made identical to secure a symmetrical main structure; due to the great difference in depth of foundations, the most economic length for span 3 (on the Hannibal side) is considerably less than the 300 ft. used, while for span 6 it is somewhat greater. A continuous truss was adopted for the two large openings, since a comparison with two simple spans showed a very appreciable saving in material, and since it possessed a marked advantage over the latter type in erection by the cantilever method, which was clearly indicated at this location. Studies were made of both simple and sub-divided panels. While either type was practicable the advantage of moderate panel lengths and sub-divided bracing appeared sufficient the justify adoption despite the somewhat better appearance of the simple bracing.

Specifications and loading

The bridge was designed according to A.A.S.H.O. specifications, with certain modifications. Provision is made for H-20 live loading with the usual impact factor. The provision for transverse and longitudinal forces, however, differs considerably from the standard specifica-

tion requirements as indicated by the following:

TRANSVERSE WIND LOADS: In combination with dead load only, the transverse wind load shall be 30 lb. per sq.ft. of vertical projection of 2 trusses, 2 handrails, and 1 floor. In combination with dead load, live load and impact, the transverse wind load shall be 50% of that used in combination with dead load only plus a load on the live load of 100 lb. per linear foot of bridge. The transverse wind load when in combination with DL+LL+I shall not be less than 300 lb. per linear foot of loaded chord and 150 lb. per linear foot on the unloaded chord.

LONGITUDINAL FORCES: Provisions shall be made for both tractive and wind forces acting in a direction parallel to the centerline of the roadway. Live load tractive forces shall be combined with the longitudinal or transverse wind loads, but longitudinal and transverse wind loads shall not be applied to the structure simultaneously. The longitudinal wind load shall be taken as 50 per cent of the transverse wind load.

The tractive force shall be 10 per cent of the live load on one lane of traffic in the case of the approach spans, and 5 per cent of the load on one traffic lane in the case of the main spans. The combination of loading shall be the same as for the transverse wind loads. The design load combinations were:

	Normal Unit Stress Per Cent
1. D + L + I @	100
2. D + 30 lb. Wind @	100
3. D + L + I + 15 lb. Wind @	125
4. D + L + I + 15 lb. Wind and Temp. @	140

Continuous truss design

The maximum live load stresses for H-20 loading were computed using the A.A.S.H.O. simplified loading, involving an equivalent uniform load and a floating concentration. For all cases of partial loading with the uniform load, the approximate method of "full joint loads" was used.

One end reaction was selected as redundant and the influence line (equal, to proper scale, to the elastic curve of the truss for a unit load at the point of redundancy) for this constructed. Preliminary values for the influence line ordinates were obtained by adjusting the known values for somewhat similar structures previously designed. Upon this basis a first design was made, and the reaction influence line constructed by the method of elastic weights. From these data a revision of stresses and sections was made and a final influence curve constructed. In no case did the ordinates to the final influence line differ from the second approximation sufficiently to affect the design sections.

The lower chord wind bracing was analyzed as a two span continuous truss; the upper bracing in each span was treated as a simple truss supported at *U1* and *U16*, with due allowance for the effect of the "breaks" in the plane of the truss. (For orientation purposes it may be noted in Fig. 1, that the horizontal top chord over the center pier spans between panel points *U16* and *U16'*, with the pier shoe at L18). This conventional assumption is obviously considerably in error; the top lateral system would appear to act more nearly as a partially continuous truss on yielding supports—*U1, U16, U16', U1'*, with *U16-U16'* as the open panel. However an approximate analysis on this basis indicated that the design sections would be unaffected.

In making the design it was noted that (a) no live load stress reversals of any consequence take place; (b) that *D*+ 30 lb. wind, using normal design stresses, governs the design of every lower chord member and (c) that the

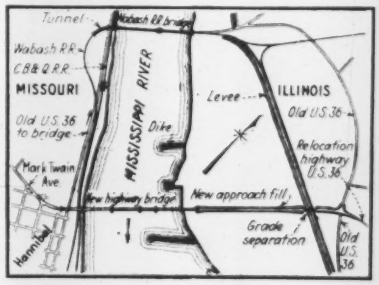


FIG. 2—LOCATION of new bridge. The circuitous route that it replaces on U. S. Highway 36 was time consuming and dangerous.

design of no other member is controlled by the wind effect. In both truss and floor members, silicon steel was used wherever it demonstrated any economic advantage. The sections and details adopted present no unusual features.

Erection

Superstructure erection began about June 1, 1935, with the erection of the girder spans on the Illinois side. These were erected when the river stage was high, with a floating derrick and 10-ton jinny-wink. The approach spans and the 300-ft main span on the Illinois side were then placed; followed by spans 1, 2, and 3 on the Missouri side. On the 300-ft. spans steel falsework bents were used at alternate panels for the first six panels; after which the remaining 120 ft. was cantilevered to the support.

Span 4 of the continuous truss was first erected by tying back to span 3, and cantilevering six panels to the first steel falsework bent, thence to similar bents at panel points 10 and 14, and from the latter point to pier 5. From this point span 5 was cantilevered twelve panels (376 ft.) to a falsework bent and thence to pier 6. The long reach used in the first erection stage of this span was a rather daring procedure, considering the great flexibility of the truss, and required unusual care and skill for its successful execution. All erection of main span steel was done by a traveling crane on the bridge floor. All steel was in place and riveted on October 18, 1935.

Weighing reactions

It has become a fairly well established procedure in the erection of two-span continuous trusses to lift the free end with jacks until the reaction (measured by the jacking forces) is in substantial agreement with the computed reaction for the load condition then prevailing, and to set the shoes at this elevation. Due to imperfections in the processes of fabrication and erection, the actual configuration of the truss may depart considerably from the theoretical form, and if the truss supports are located in the theoretically correct positions, the unstrained profile of the actual truss does not conform to them and the actual reactions will obviously not coincide with the theoretical values. The erection procedure referred to eliminates this discrepancy, and, within the limits of accuracy of the process, insures that the actual and computed reactions agree.

The practical importance of this adjustment will depend largely upon the rigidity of the truss. The Hannibal continuous truss is quite flexible, and the reaction required to displace the end of the truss 1 inch is only 2,300 lb. This will change the unit stress in *U16-U18* (the member most affected by change in end reactions) about 170 lb. per sq.in. —approximately 0.5 per cent of the allowable unit stress in the member. Any great refinement in the adjustment of the reactions is clearly unnecessary in such a case.

As previously stated, the truss was erected from the west side, and final closure was made by placing the shoes at pier 6. Two 150-ton hydraulic jacks were used to lift the structure, which at this stage had all the steel including bracing, floorbeams, stringers, and handrail in place, but none of the roadway slab poured. A computation of the end reaction, made from a careful take-off of the steel weights, gave a value of 247.5 kips. The end of the truss was lifted some 4 in. above normal position to permit the temporary placing of the shoes, then dropped to normal position, and the operation repeated as a check. When the ends were finally levelled off in about correct theoretical location, the average of the jack readings was 245.5, a variation of less than 1 per cent, and the deviation of the individual jack readings from the mean was less than 2½ per cent. Since these variations were within the limits of accuracy practically attainable under the condition, the shoes were set in this position without further adjustment.

As a matter of scientific interest rather than for its importance as regards the behavior of this particular structure, a check on the jacking forces was made by means of strain gage measurements taken at four "corner" locations on the member *U17-U18* in each truss. The specifications required the steel contractor to set gage plugs in these members in the shop, and zero readings were taken on the ground on the four gauge lengths for each member, and another set when the truss was erected and the ends jacked into final position. From these data, the average stress in the member and the reaction required to produce it were computed. This value was found to be about 7 per cent less than the reaction determined by the

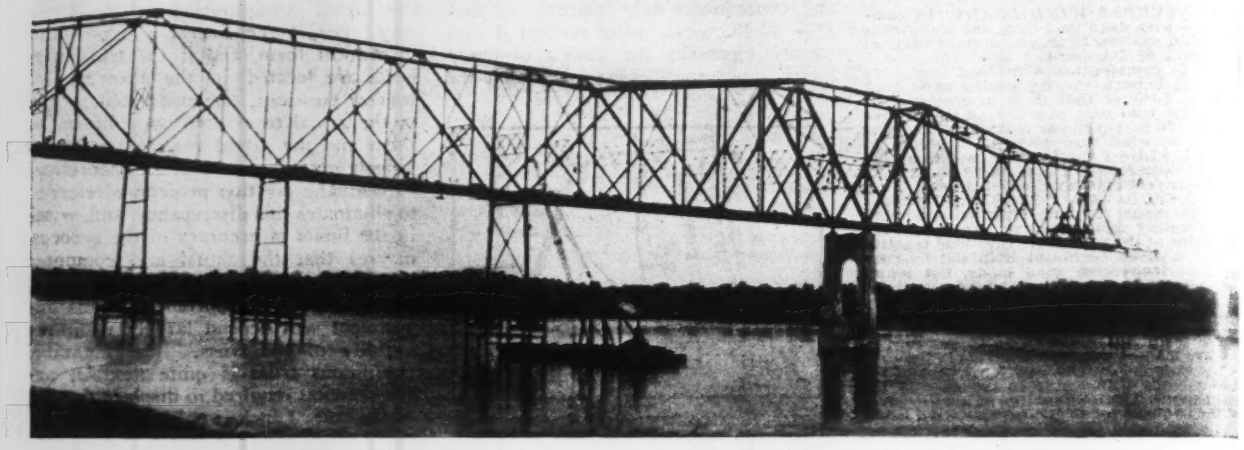


FIG. 3—A JUMP of 376 ft. cantilevering from the center pier to a falsework bent, featured the erection of span 5

jacks. Considering the obvious impossibility of attaining a high degree of accuracy either in the jack readings or the extensometer measurements under the conditions surrounding the work, this was regarded as a very satisfactory check. The measurements were made with a 10-in. Whittemore strain gage.

The slab construction schedule on the floor of the continuous span involved the pouring of panels six to twelve in span 4, then a similar section in span 5, then the remaining inner panels in spans 5 and 4 and finally the 6 outside panels in each of the spans.

The bridge contains 1,040 tons of structural silicon steel; 1,600 tons of structural carbon steel; 323 tons of reinforcing steel; 7,865 yards of concrete in the foundations, and 1,485 yards in the floor slab and curb. The total cost of the structure was $673,000, divided into $271,000 for the substructure and $402,000 for the superstructure The Union Bridge Co. of Kansas City, Missouri, was contractor for the substructure, with L. F. Greble, superintendent of construction. The Mount Vernon Bridge Co., Mount Vernon, Ohio, was contractor for the superstructure, with Walter Smith, superintendent of construction.

The design and supervision of the construction of the bridge was under the direction of Sverdrup and Parcel, consulting engineers, St. Louis, S. J. White, resident engineer in charge of construction, and E. B. Murer assistant resident engineer. Chester I. Duncan was resident engineer inspector for the Federal Public Works Administration.

Domestic Water Consumption in a Large Construction Camp

THE GRAND COULEE DAM project on the Columbia River in eastern Washington gives opportunity to record domestic water consumption figures in two construction camps. The government camp on the west side of the river has its own supply entirely separate from that of the contractor's camp on the east side of the river. Very different conditions obtain in the two camps and figures are available on the quantities of water consumed in both.

The government camp is a permanent town with structures and facilities provided for use after the construction period has passed. The population is now 525. The potable water supply is taken from a large spring in Fiddle Creek just west of the camp whence the flow is 20 to 40 g.p.m. This flow will be adequate for all purposes, it is believed, after the construction period is over. Meantime an auxiliary supply for fire protection, sprinkling gardens, etc., has been installed and is piped to every house, thus giving each consumer two kinds of water.

Water from the two sources is stored in adjoining reservoirs on the steep hill just west of the settlement. A gravity flow from the spring passes continually into a covered, screened, concrete-lined reservoir from which there is an overflow into the auxiliary open reservoir adjoining. The latter is kept full by pumping from the Columbia River. The pumping plant on a pier of the highway bridge across the river, contains two 500-g.p.m. pumps automatically controlled by float valves in the reservoir.

During the present season lawns have been started around many of the town residences, entailing a rather heavy sprinkling demand. However, no roof sprinkling is done in this camp as is the case on the other side of the river. A typical month in the summer of 1936 showed that in the domestic supply to the government camp the demand was 49½ g.p.d. per capita and that the demand on the auxiliary system was about 224 g.p.d. per capita, thus, say, a 275-g.p.d. per capita total.

On the eastern side of the river Mason City has a population of 2,500, of which about 1,500 are in the mens' dormitories; the other 1,000 are largely in separate houses (married quarters) and in the hospital, hotel, women's dormitory, etc. The lawn area in Mason City is relatively much less than in the government camp but this is more than offset by a considerable amount of street sprinkling and the use of sprays on roofs (for cooling) on many of the dormitory cabins. There is only one water supply in Mason City. This is pumped from the Columbia River above the camp and is stored in tanks on the hillside to the east of the settlement. Three 500-g.p.m. pumps, automatically controlled by float valves, provide the supply which is chlorinated at the tanks. Householders are not charged for water, thus encouraging the sprinkling of lawns and other uses. It has been expedient to divert some of this domestic supply for construction uses so that of the 400 g.p.d. per capita which represents the total amount used, it is estimated that about one-third is diverted to other than "city" uses. Hence a rough figure for the Mason City consumption is about 265 g.p.d. per capita.

Research Notes

Hydraulic and Structural Work at Case School

By George E. Barnes and Fred L. Plummer
Case School of Applied Science
Cleveland, Ohio

THE CIVIL ENGINEERING department at Case School of Applied Science maintains four laboratories for studies in hydraulic engineering, sanitary engineering, the structural and soils questions, and construction materials. All of these are utilized both in undergraduate and graduate training, and for research by students and faculty. Thesis work is frequently a laboratory study, and some research is usually under way as a cooperative enterprise between the faculty and industrial or public agencies. Measured by volume of completed work, the hydraulic and the structural and soils laboratories have been most active.

Research facilities

The hydraulics laboratory, housed in the Warner Building, was provided and equipped in 1928 through the generosity of the late Worcester Reed Warner, and was greatly enlarged and redesigned in 1934, with the following features:

The equipment exclusive of shop occupies about 6,000 sq.ft. of space on the ground and second floors. A trucking entrance is serviced by a 3-ton crane. A flexible recirculation system permits handling of flows up to 1,000 gal. per min. under 350 ft. head, or 3,000 gal. per min. under low head. Centrifugal pumps, arranged for testing, deliver water from a 50,000-gal. reservoir under the ground floor to all units on the two floors, either by direct pressure or through a constant level tank for insuring absolutely steady flow. The flow is measured by 4x12-in. venturi tubes, and is read by indicating, recording, and totalizing meters. Flow may also be measured by weirs, orifices, and at any point in the pipe lines by a pitometer. All of these measuring devices may be calibrated directly by displacement in six volumetric receiving tanks of 15,000 gal. total capacity, and arranged for continuous operation.

Among the principal units is the testing flume, 3x3 ft. in section and 90 ft. long, for open channel and model studies. The flume includes a 9 ft. length with sides of plate glass, for transverse inspection and photography. On the ground floor is the river flume, 44 ft. long, 12 ft. wide, and of 5.5 ft. maximum depth. Accessories include baffled inlet chambers, adjustable tailwater weirs, batteries of hook and point gages, a laboratory benchmark and fixed stanchion for levelling, and instruments for determining velocity in open channels. The laboratory also contains several types of hydraulic machinery, and tools for pipe fitting and model building. Photographic equipment is available.

The structural and soils laboratory occupies about 1,000 sq.ft. of floor space in the Main Building and is fully equipped for the analysis of statically indeterminate structures by the use of small scale models. The equipment includes the Beggs deformeter gages and microscopes, the Werner deformeters, the Gottschalk continostat, Huggenberger tensometers, Ames dials, and other instruments suitable for measuring small deflections and strains. Polariscopes are available for the study of stress concentrations by the use of polarized light. The laboratory also includes power and hand tools for fabricating accurate scale models in wood, rubber, celluloid, bakelite, and other suitable materials.

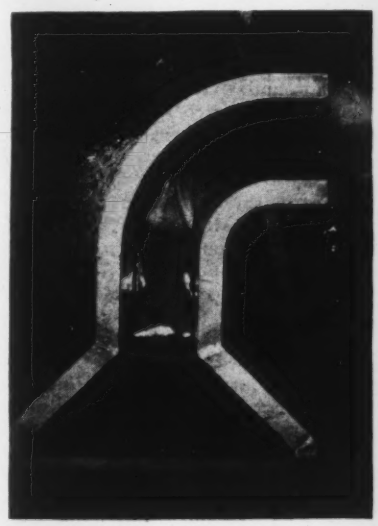


FIG. 1—Constricted outlet channel from Wards Island (New York) sewage plant grit chambers reproduced in a 1:6 model.

Hydraulic studies

Among the current activities in the hydraulic laboratory is work on a 1:6 scale model of one unit of four grit chambers at the Wards Island sewage plant in New York City. The model was built in 1934 and the design provided proper average velocity at all rates of flow, without regulation, by means of a narrow or constricted outlet channel which acts as a broad crested weir, freely discharging at low flows and submerged at higher flows. The outlet channel has a level floor, terminating with a parabolic fall in a downtake shaft which will carry the sewage to a tunnel crossing the East River. At low flows, which were studied first as an undergraduate thesis project (A. H. Horkan and E. J. Leuty, 1934), the outlet channel is the control section, and water surface elevation in the grit chamber is a function of critical depth and assumed losses in the transition. At high flows the water surface is a function of the hydraulic gradient in the shaft and losses. With additional equipment and tailwater regulation, the model is now being operated for study on high flow conditions.

In 1934-35, hydraulic model studies were made on eleven dams for the Muskingum flood control project, with a laboratory staff drawn both from the personnel at the school and from the district office, U. S. Engineer Department, Zanesville, Ohio. The outlet works, stilling basins, masonry spillways and other features governing hydraulic performance for the Wills Creek, Charles Mill, Dover, Tappan, Clendening, Piedmont, Pleasant Hill, Boliver, Senecaville, Mohicanville and Mohawk Dams were tested with undistorted models varying in scale from 1:20 to 1:40. Each model included some or all of the following features:

Reservoir approach topography at the control works; intake tower and gates; outlet conduits or tunnels; stilling basin; outlet channel; and spillway.

One of the more complex model layouts is for the Pleasant Hill Dam as shown in Fig. 2. The model is on a 1:30 scale. It includes a sheet steel gate tower, with continuously open orifices for stream flow regulation; a shaft spillway of the morning glory type, spun from aluminum sheet; an outlet tunnel varying in diameter from 15 to 20 ft., of horseshoe section and fabricated from sheet steel, a wye-junction molded in pyralin; and a stilling basin, to reduce the energy of released waters by means of a hydraulic jump.

Comparison between model and prototype in the case of the Charles Mill

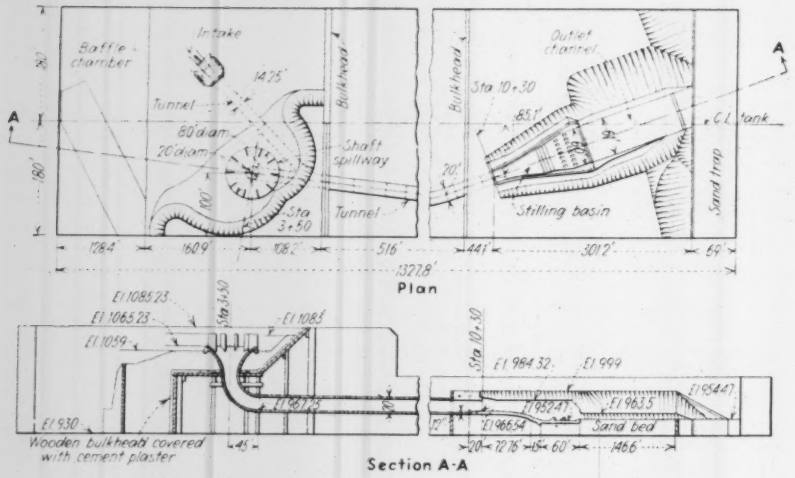


FIG. 2—Outlet works model (1:30 scale) of the Pleasant Hill Dam, a part of the Muskingum flood control project, as built in the Case School laboratory as a step in the design procedure.

Dam (now under construction) is indicated in Fig. 3, showing the model in action, and the actual outlet structure releasing low flow.

In all of these model studies the outlet works was calibrated for the relation between reservoir level and discharge, for various combinations of gate opening and anticipated tailwater levels. In many cases the studies resulted in substantial changes being made in the proposed design. Perhaps the most important single group of findings related to proper design of the several stilling basins. Briefly, it was found to be of paramount importance to proportion the outlet portal and stilling basin, to secure uniform distribution of flow across the apron; to relate tunnel invert elevation to tailwater level in such fashion as to insure adequate momentum of discharge against tailwater backpressure; to incorporate baffle piers in the stilling basin for the purpose of holding the jump on the apron for widely divergent rates of flow; and to include a low stepped-faced terminal sill at the end of the stilling basin, to reduce scour in the channel below.

The model study findings for the Muskingum dams are incorporated in a series of eleven reports submitted by the senior author to Lieut. Col. J. D. Arthur, Jr., District Engineer, Zanesville, Ohio. A general summary is given in a paper by George E. Barnes and J. G. Jobes, entitled "Construction and Testing of Hydraulic Models of Outlet Works, Muskingum Watershed Project," to be published in an early issue of *Proceedings*, Am. Soc. C. E., and which appeared in abstract form in *Civil Engineering* for January, 1936.

Since completion of the official tests, the models have remained in the laboratory for further research and instruction purposes. One of the most difficult tasks in model studies is the measurement of hydraulic gradients by piezometers for the determination of n for the model tunnels, where high velocities and irregular distribution of velocities occur. The model of the tunnel for the Pleasant Hill Dam has been very carefully reconstructed, to take more precise measurements. Results to date indicate an apparent Kutter's n below 0.008 for high flows, indicating that the inlet conditions to the tunnel are such as to produce abnormal velocity distribution in the tubes, with low velocities along the wetted surface, and abnormally high velocities in the center. The value of n varies with the flow, showing inconstant distribution.

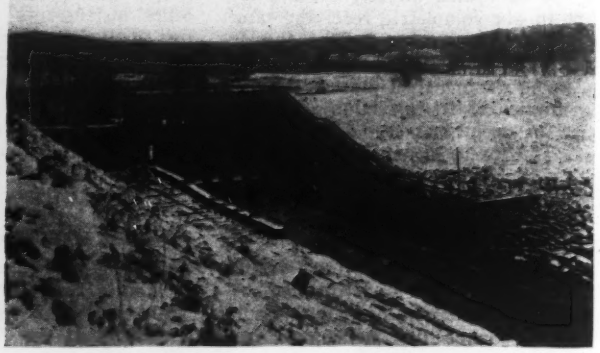
Studies on a venturi flume have continued during the present year. The flume has a level invert with 18-in. channel and 6-in. throat. It has been calibrated for flows from 0.25 to 5.0 sec. ft., with depths controlled by an adjustable tailgate, so that it operates above and below the critical range. Analysis of the coefficient of discharge is under way, to correlate this factor with some suitable dimensionless ratio which incorporates the physical quantities affecting discharge.

Additional hydraulic research includes assignments from industrial concerns on design and setting of ejector inlets for swimming pools and on performance of self-priming centrifugal pumps.

Structural research

Research problems in the structural models laboratory may be divided into three groups. The first consists of studies made with large scale three-dimensional models. These have usually been made in cooperation with industrial agencies. A study continued over a period of three years, was conducted in cooperation with the Goodyear Zeppelin Corp. in which two large models were constructed of celluloid tubing and fine wire. Sections of a typical airship framework were constructed, and the stresses and distortions under various load conditions were investigated. A special strain gage was developed for these studies. In preparation for the tests an exhaustive study was made of all materials suggested as suitable for such models. The results of the studies were presented in report form to the Goodyear corporation whose engineers cooperated in their planning and conduct. Partial results are also

FIG. 3—Model and prototype of Charles Mill Dam of the Muskingum Valley project. This is one of eleven dams on which Case School model studies were made.



available in a thesis of L. H. Stewart and G. B. Earnest.

A second study carried out in cooperation with the engineering firm of Wilbur Watson and Associates, included the construction and testing of a model of a long-span solid-rib two-hinged arch bridge of somewhat unusual design. A 1:36 scale model of celluloid was cut from sheets and assembled to simulate the proposed structural shapes. This model was tested to determine the distribution of wind stresses and the participation of the floor system and lateral bracing in distributing vertical loads between the two main box-girder arches. (Theses of Leslie, Artner and Davis.)

A current project of this type includes the use of wood and celluloid models in testing a new type of plywood rigid frame construction used in the Hall of Progress for the Great Lakes Exposition now being held in Cleveland. The building was designed by the architectural firm of Hayes and Simpson with C. Merrill Barber as engineer. The two span frames which are 60 ft. long and about 30 ft. high consist essentially of two 2 x 10's on edge both top and bottom, and encased in ⅜-in. plywood. (*ENR*, May 21, 1936, p. 751). The question of nailing or glueing the pieces together was studied with a decision in this case that nailing alone should be used. A complete nailing schedule similar to the rivet spacing on plate girders was developed and included in the specifications and plans. A four-tenths scale wood model and a one-twelfth scale celluloid model were tested for both vertical and horizontal loads. Results are not yet published. Other three dimensional model studies include a suspension bridge tower, building frames under horizontal loads, stress distribution in circular tanks, and stresses in eccentric riveted and welded joints.

The second group of studies is on structures which can conveniently be represented by one-plane models. One method of study is by aid of splines; a supply of wood, celluloid, and metal splines with crude wood joiners being kept on hand at all times. These can be used to simulate any structural framework quickly and will yield results which are often surprisingly accurate. Another method makes use of the Gottschalk continostat by which it is possible to trace directly an accurate influence line for the redundant forces of certain continuous frames. The Werner deformeters, developed in cooperation with the laboratory, may also be used. These are described in the June, 1936, issue of *Civil Engineering*. A fourth and more accurate method involves the use of the well known Begg's deformeter gages and microscopes. A number of commercial problems including the analysis of continuous structures for bridges or buildings have been studied by these means. A series of studies of the participation of deck structures

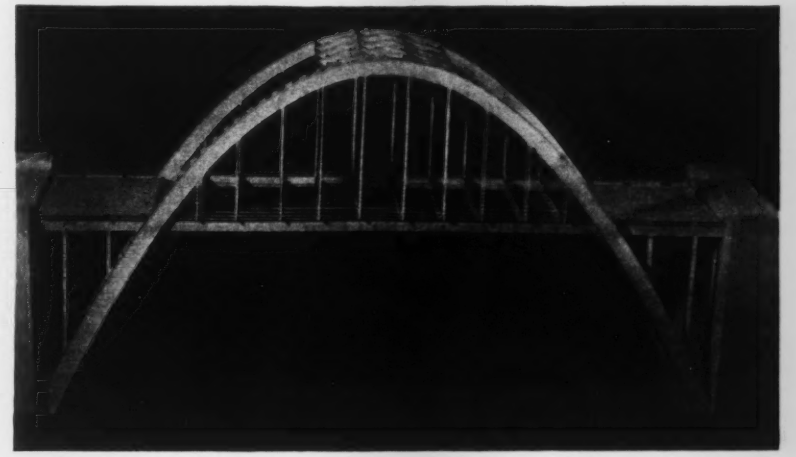


FIG. 4—Celluloid model of a long span two-hinged steel arch bridge used to study wind stress distribution and floor participation in distributing vertical loads to the ribs.

in carrying the loads on reinforced concrete bridges has been carried on, using the Begg's apparatus. The development of crude spline models for preliminary design purposes and for demonstration to designers is receiving current attention.

The third group of studies has to do with problems in internal stress distribution. Sheet rubber models have been found very valuable for the determination of qualitative results. For example, the tendencies toward distortion in welded and riveted joints and in irregular sections due to inherent eccentricities can be very vividly demonstrated, and stress concentrations near holes and notches can be approximately determined. The photo-elastic method of studying stress distribution is now well known. The laboratory has recently assisted in a series of studies carried on in cooperation with the U. S. Engineer Office at Zanesville, Ohio. These studies included the determination of principal and maximum shear stresses around the openings in a model of the reinforced concrete Dover Dam, and a study of shearing stresses in and under earth embankments.

The laboratory is cooperating on photoelastic and other structural model studies now under way in the Huntington, W. Va., District Office, U. S. Engineer Department. These include the effect on stress distribution of horizontal and vertical joints in a solid masonry dam (Bluestone Project, Hinton, West Va.), and also stress concentrations around major openings in the structure.

There is now under way a series of tests to determinate the suitability of gelatin and marblette for photoelastic studies. Gelatin has a sufficiently high stress-optical constant to produce color fringes due to its own weight and thus make possible the determination of stress due to body forces. This is not true for other photoelastic materials. Considerable physical data will soon be available for publication.

Operating Results of St. Paul Water System

DURING 1935 the Water Department of St. Paul, Minn. in its annual report states that it delivered an average of 76.2 gal. per capita or 354 gal. per tap, to the total of 292,000 people served, including South St. Paul and West St. Paul. The city is 99.9 per cent metered. The domestic consumption is 56 per cent and commercial use accounts for the remaining 44 per cent of the total. On the maximum day, July 30, twice the average amount of water was pumped. St. Paul has a population of 485 per mile of water mains and a total area of 55.44 sq. mi. Costs per million gallons are as follows: Administration and general, $17.83; production, $12.63; distribution, $21.53; fixed charges, $56.55; total $108.54. The revenue per m.g. was $117.10. In the production item filtration accounted for $6.35 as against $6.93 in 1934. Filter washing required 2.53 per cent of the total water pumped. Runs were 44 hr. long. Chemicals used were as follows: Aluminum sulphate, 0.81 grains per gallon; chlorine, 0.75 p.p.m.; ammonia, 0.16 p.p.m.; chemicals cost $1.98 per m.g. The turbidity of influent was 5 p.p.m. and of effluent nil. An average of 666 bacteria per c.c. in the influent was reduced to 7 in the effluent. Likewise the influent colon index of 8.51 was reduced to none. Leonard N. Thompson is general superintendent and engineer.

Aeration Power Unit Measures Sewage Plant Efficiency

Kilowatt hours per pound of B.O.D. removed, suggested to replace hp. per m.g.d., is now required in plans submitted for approval to Illinois Sanitary Water Board

By W. H. Wiseley and C. W. Klassen
Assistant Sanitary Engineer and Chief Sanitary Engineer, respectively, Division of Sanitary Engineering, Illinois State Board of Health

PRESENT UNITS for the expression of aeration power consumption in activated sludge plants have been the subject of much discussion and criticism by operators, consulting engineers and aeration equipment manufacturers. Power consumption is of primary importance to the municipality because the cost of operating any sewage treatment works must be within the financing ability of the municipality. Without proper plant operation, the outlet stream suffers, and thus any state body having control over stream pollution is directly interested in this matter. Also, such state agencies, especially the departments of health, frequently carry on tests of new plants for the purpose of determining the effectiveness and efficiency of aeration equipment. Anyone who has been confronted with the problem of analyzing or reporting either test or operation data on aeration power consumption in activated sludge plants will realize the need for a more suitable unit for the expression of such data.

Going back to the earliest test data on mechanical aerators in Illinois, the unit first used in specifications was "horse power per million gallons," which term obviously has no meaning since it expresses a "rate per quantity." This unit, like Topsy, "jus' growed" into general use and even today power consumption is frequently incorrectly stated in horse power per million gallons, although the figure actually calculated is "horse power per million gallons per day" (hp. per m.g.d.).

The power unit most commonly used at this time in writing aerator specifications and in reporting power consumption by operators is "hp. per m.g.d.," although in some cases this is simplified slightly to "kilowatt hours per million gallons" (kw.-hr. per m.g.). However, both of these expressions place the power consumption on the basis of the treated sewage volume only and do not take into consideration the concentration or strength of the sewage being treated. As the concentration of sewage is highly variable in different cities and also changes considerably with the season at any one plant it is evident that a distorted conclusion from the power figure can result. For instance, a plant may be tested during a wet weather month when the sewage flow is high and may show what appears to be a satisfactory figure on hp. per m.g.d. basis, but when tested during a dry month the power consumption by this unit might appear high, even though more work was actually being accomplished by the same number of aeration units.

B.O.D. measures efficiency

A proper aeration power unit should be based on the energy required to do a given amount of work. In sewage treatment the best present method of measuring the work done is by means of the biochemical oxygen demand (B.O.D.) determination which is the generally accepted efficiency test for a treatment plant as a hole or for any principal individual plant unit. If the number of kilowatt hours used by the aeration equipment during a given time is divided by the number of pounds of B.O.D. removed by aeration in the same time, the resulting figure would represent "kilowatt hours per pound B.O.D. removed by aeration."

It is believed that this unit is much better adapted to reporting test data than is "hp. per m.g.d." or "kw.-hr. per m.g." because it is a definite expression of the energy required to do a unit of work. Future specifications submitted to the Illinois Sanitary Water Board for approval will be required to express power consumption in this or a similar manner. While two methods of expressing a "work done" unit are offered in the tabulation, it is considered that the expression "kw.-hr. per pound B.O.D. removed" is best adapted to use in specifications.

The term "pounds B.O.D. reduced per kw.-hr." is used by Kessler in reporting the results obtained with an experimental aerator at Monroe, Wis. This unit is the reciprocal of "kw.-hr. per pound B.O.D. removed (or reduced)" and serves equally well in placing power consumption on a "work done" foundation. The unit suggested by Kessler appears to be especially well adapted to reporting power data by plant operators.

The tabulation below shows some typical test and operation data on three Illinois activated sludge plants and illustrates how the units "hp. per m.g.d." and "kw.-hr. per m.g." can be misleading with varying sewage flows.

Assumed figures for a hypothetical plant treating a normal strength sewage at an aeration power consumption of 20 hp. per m.g.d. is included for comparison. A 35 per cent removal of B.O.D. in primary treatment was assumed and the effluent of 15 p. p. m. B.O.D. meets the requirements of the Illinois State Sanitary Water Board. These conditions are frequently stated in aerator specifications.

A study of the tabulation brings out some interesting comparisons. For plant A, the hp. per m.g.d. figure was less than 20 during the wet weather test, but was extremely unsatisfactory on the basis of the dry weather conditions. Actually 35 per cent less energy was used in removing one pound of B.O.D. during the dry weather test. Also on

COMPARISON OF UNITS FOR REPORTING AERATION POWER CONSUMPTION IN ACTIVATED SLUDGE SEWAGE TREATMENT WORKS

Plant	Nature of Sewage Flow	Period of Data (Days)	Sewage Flow Treated (M.G.D.)	5-Day B.O.D. of Sewage (P.P.M.)			Lb. B.O.D. Removed by Aeration	Aeration Power				
								Kw.-Hr. per Day Consumed	Comparison of Units			
				Raw	Settled	Final			Kw.-Hr. per M.G.	HP. per M.G.D.	Kw.-Hr. per Lb. B.O.D. Removed by Aeration	Lb. B.O.D. Removed by Aeration per Kw.-Hr.
Hypothetical	.....	.....	1.0	200	130	15	958	359	359	20	0.375	2.67
A	W.W.F.	1	0.277	120	91	16.8	171	88.5	319	17.8	0.517	1.94
A	D.W.F.	1	0.177	570	330	6.9	476	161	907	50.5	0.338	2.96
B	W.W.F.	31	0.755	203	141	8.4	834	184.2	244	13.6	0.221	4.53
B	D.W.F.	30	0.580	372	208	11.4	946	189.6	327	18.2	0.20	4.99
C	W.W.F.	31	0.945	75	55	4.2	400	341	361	20.1	0.854	1.17
C	D.W.F.	30	0.620	191	117	18.5	509	286	461	25.7	0.562	1.78

the "work done" basis, the dry weather test results compare quite favorably with the hypothetical plant whereas the wet weather test results do not.

The hp. per m.g.d. figures for plant B are quite favorable for both sets of data, although here again it is shown that more work was actually done during the dry weather condition. The data on this plant are interesting because of the very high efficiency shown when compared with the hypothetical plant.

The data shown for plant C indicate that the aeration equipment was functioning within a reasonable range on the hp. per m.g.d. basis for both conditions given. On the "work done" basis, however, the aerators are shown to be underloaded, indicating possibly that some of the aeration tanks could be removed from service. A higher actual efficiency is again shown for the dry weather condition, even though a higher hp. per m.g.d. is calculated.

It will be noted that the calculation of the suggested unit, kw.-hr. per pound B.O.D. removed, also eliminates the primary settling tank from consideration because most specifications state the limits of raw sewage strength. It is obviously not logical to require the aeration equipment manufacturer to guarantee the operation of other plant units as well as the equipment he furnishes. Also it is well to eliminate the final settling tank in testing, which is sometimes done by stating in the specifications that the aerator effluent sample will be taken from the supernatant of a one-liter sample of aerated mixed liquor that has been settled in a graduate for one hour. These considerations are of consequence only in connection with the testing of equipment.

From the foregoing it is apparent that an aeration power unit based on the work accomplished has considerably more meaning and value than the units used at present which are based on the treated sewage volume only. In suggesting the unit "kw.-hr. per pound B.O.D. removed" it is felt that a practical unit which is definite and can be safely compared, is offered. It is further believed that by the adoption of this unit or one of similar meaning by engineers and chemists, power data will be much more comparable and valuable. The general adoption of a standard unit is urged.

Making Structural Engineers in College

Some suggestions for meeting the modern needs of the student for more cultural courses and at the same time for more intensive technical training

By Hale Sutherland
Professor of Civil Engineering, Lehigh University, Bethlehem, Pa.

A DILEMMA confronts college authorities striving to turn out structural engineers who can take their place in a world growing more complex and more specialized. They are asked to give the students more economics, English, history and language and at the same time to intensify the technical studies to include many new theories of analysis and more fundamentals. The four-year curriculum without these added courses is often too crowded. What can be done is a live subject on which Hale Sutherland, head of the civil engineering department at Lehigh University, contributed some significant discussion at the recent convention of the Society for the Promotion of Engineering Education at Madison, Wis. His analysis leads him to the conclusion that the time is here for important changes in our teaching procedures.—EDITOR.

GREAT as have been the advances in structural engineering in the last fifty years it is evident that the mass of new material now available constitutes a rather greater and more significant increment than has been the rule over equal periods in the past. Consequently the expansive pressure upon the structural courses in our engineering colleges is at a high gage mark today, so much so that it would seem that the time is here for certain significant changes in our procedures.

In the past as the pressure of new theories and processes increased we have added to the time allotment in those fields most evidencing progress and have subtracted elsewhere, notably from the time given to general collegiate education. Today, however, the current is moving the other way and in its turn great pressure exists for increased allotments in such fields as English, economics, history and government. Rather generally and definitely it has been decided that the engineering graduate must be equipped in some measure at least as a man of culture, of affairs and as a citizen. We recognize a responsibility that the engineer be trained to do his share in shaping our social policies through this period of accelerated social evolution. At a moment when the mass of the technical is rapidly growing, we can no longer give more time to the technical in the four-year course. The dilemma is acute.

Some schools are meeting the situation by a wise move which should be universal. In engineering college the student carries through a three-fold task: he gains familiarity with a large amount of descriptive matter, facts concerning materials and procedures; he acquires manual skill as draftsman and as surveyor; and he gains competency, to a degree, as analyst in the field of structural science. By decreasing to an absolute minimum the class time given to description, to surveying and drafting, room is made for drill in analysis. Much descriptive matter can be covered by required outside reading and report. It is well that structural engineers should note that this same pressure to new basic knowledge exists in the hydraulic field, exerting the same imperative for more analytical drill.

It is probably academic to discuss the five or six-year program and it seems likely that the mere multiplication of the present four-year plan by some factor greater than one will never be the accepted solution of the difficulty imposed by the increase of the content of our science. Certain fundamental reasons veto this sort of time extension: poverty of parents; the mediocrity of a large proportion of our students; lack of practical contact with engineering work in formative years; and the desire of the normal young man for active work and his impatience with theoretical study.

Nevertheless the only known way to secure the additional time needed for the proper reflective study and assimilation of the immense amount of matter comprised in a comprehensive course in structural engineering is to add to the present four-year curriculum for that part of the student body competent to aspire to become practitioners. Whatever the standards may be in the rest of the field of civil engineering, it is time that it be generally understood that adequate preparation for structural engineering demands the fifth post-graduate year. It would be well to add this proviso: the fifth year of specialization should be preceded by a year or more of practical work in field or drafting room. And it is certain that an increasing number, as the years go on, will carry through their study and research to the doctorate level. This is and may long remain an individual matter beyond the range of group dicta.

The plan of a year of graduate study escapes actually or potentially the difficulties of the so-called five-year plan because only students of proved ability and definite purpose elect this extra year, recognizing the need of this training as preliminary to competent technical practice. The economic obstacle and long detention of the student from the practical world are difficulties jointly solved, in some measure at least, by the requirement that the summer vacations be spent in enginering work, and when practicable by the intervention of this year of practice between the fourth and fifth years in school. It is probable that the colleges should make systematic arrangements with structural concerns, to insure this vacation and early post-graduate work.

Changes in curriculum

Two changes in undergraduate courses and one in the fifth year are rather generally imperative at this time. The familiar one-term course in strength of materials, which reaches a peak with consideration of either the moment-area or the elastic weight theorems, is no longer adequate even for the civil engineering student with no special interest in structures. Juvenile specialization is anything but a sure index of future activity, and the basic training of all should be thorough enough to insure a foundation for structural study on the job after college. A two-term course, in mechanics for undergraduates should be required with the inclusion of such topics as general bending, impact and energy loads, curved beams, flat plates, thick cylinders, torsional stresses in structural shapes and an introduction to indeterminate structures by the way of deflections.

The second undergraduate omission to be rectified is our failure to treat vibration seriously enough so that a foundation is provided for later study of dynamic and earthquake effects. This topic might well be considered in either the course in physics or in strength of materials.

In the graduate year a two-semester course in mathematics should carry the student beyond the range of the usual undergraduate calculus, considering a carefully selected and coordinated series of methods which are basic in higher structural theory. For example, difference equations are becoming recognized as a powerful tool in a variety of analyses; hyperbolic functions are barely touched upon by the usual undergraduate. Competency should be gained with these two and other methods.

In consequence of this ever-flowing flood of new material from field, from engineering office and from research laboratory, the function of the coordinator of knowledge has an importance greater than ever before. If the new is to be assimilated to the old to form a coherent unified body of science some must give their time to study of the new, to its appraisal and often restatement, to its tying in with all the rest of fact and theory. This is a process of boiling down and the result is new and systematized presentation facilitating the efforts of future students. We cannot all be research workers and innovators else specialism will grow narrower and specialists more and more isolated, lacking that all-round grasp of situations essential for worthy professional practice in the application of structural science and art. The literary trail of the coordinator may be a text and it may simply be class notes available only to a few but it will be revelation of the passage of an active enquiring intellect engaged in a socially useful task. It is pleasing to note as one of the trends of our profession that probably more than formerly college executives are placing high valuation on this type of activity and no longer reserve preferment to the innovator alone.

Asphalt Patching Trues Up Automobile Race Track

Indianapolis motor speedway's famous brick surface roughened by base failures is smoothed by sand rock asphalt patches

By A. O. Hastings
Consulting Engineer, Indianapolis, Ind.

THE INDIANAPOLIS motor speedway built in 1909 is the great outdoor laboratory which has contributed beyond estimate to the wonderful progress of the automotive industry. Advancement and refinement of motor equipment is easily traceable to experimental work on this, the greatest international speedway. The speedway grounds, located near the northwest city limits of Indianapolis, Ind., comprise over 400 acres, with the 2½-mile oval race course, grandstands to seat 65,000 persons and ample parking space for 15,000 automobiles.

Original construction

The track is 2½-mi., measured on the track 3 ft. from the inside edge of the pavement. It consists of two straightaways on the east and west sides of the oval, each 3,300 ft. long, two short straightaways on the north and south, each 660 ft. long, and four curves of 90 deg. central angle connecting the straightaways, each curve 1,320 ft. long, a total of 13,200 ft. The straightaways are paved 50 ft. wide and the curves are widened to 60 ft. The curves are superelevated with run-off at each end extending onto the straightaways about 300 ft. The maximum superelevation is 0.16 ft. per foot of width. The curves were not spiraled, but the drivers generally hold to the outside of straightaways and cut into the inside of curves, thus following a spiral in driving.

The track was graded in 1909 and surfaced with pit run gravel about 4 in. thick, upon which was placed a bituminous-macadam course 2 in. thick, using a low melting point tar as binder. A race was scheduled on this macadam, but could not be completed on account of the roughness of the track. It was then decided to surface the track with brick.

The old bituminous macadam was leveled up with sand and the track paved with 4-in. repressed brick, monolithic construction. Nothing was done in this original construction to take care of expansion and contraction due to temperature changes, and soon the bricks heaved and several expansion joints had to be installed. These joints were made by removing one or two rows of brick and filling the space with a sand-bitumen mix. Expansion and contraction has done considerable damage, causing many longitudinal and diagonal cracks to form. These cracks permitted rain water to get into the sand cushion and base and cause shifting of the sand, particularly on superelevated curves. The track became rough in spots, this roughness causing the drivers plenty of trouble.

When paving the track originally, the outside 10 ft. on curves was given extra superelevation of about 0.3 ft. per foot, the thought being that a car driving onto this area would have help in getting back onto the track proper. This worked all right for lower speeds, but not so at the high speeds of today. Instead of helping the driver it was an extra hazard; cars driven onto this change in superelevation immediately went out of control, and many went over the old wall around the ends of the track.

There was, on the inside of curves and end straightaways, a 10-ft. concrete paved apron or zone with a concrete wall inside of that. This wall proved a menace rather than a help to the drivers. If a driver lost control on superelevated curves he naturally drifted down to the inside and many times cars glanced off

WHERE A PATCH THICKNESS of over 1 in. was necessary a hot-mix binder course was used and surfaced with a thin wearing course of rock asphalt.

PLACING THE THIN WEARING COURSE of rock asphalt required careful work in feather edging the asphalt onto the brick bordering the patch.

this inside wall and then went over the outside wall.

In the spring of 1935 it was decided by the management of the speedway to revamp the track and put into this revision all of the safety factors possible. Work was begun in June, 1935, and completed a short time before the race, May 30, 1936.

The existing inside wall at each end of the track was removed and an oiled earth safety zone was constructed 50 ft. in width. The extra superelevation on the outer 10 ft. of curves was removed and repaved at the superelevation prevailing on the remainder of the track. A new reinforced concrete wall, 3 ft. high, with its face perpendicular to the cross-sectional grade, was constructed around each end of the oval and immediately inside of the old concrete wall which was left in place. There was used in this concrete construction over 30,000 cu.yd. of concrete and over 60 tons of reinforcing steel.

True grades established

The track surface was improved by patching with bituminous hot mix binder and Kentucky rock asphalt wearing surface. Irregularities in grade were carefully determined by survey. True grades were established and the surface brought to these grades by the application of bituminous hot mix on areas where over 1 in. in thickness was required, then placing a rock asphalt surface, feathering out with the rock asphalt to a sand grain thickness at edges. The old brick was given a paint coat of 50-penetration asphalt, cutback with straight-run gasoline, before binder or rock asphalt was placed.

This patch work on the track was completed in November, 1935, and no traffic was permitted until the track was opened this spring for demonstration trials for the 1936 race. The area thus patched is about one-third of the paved area of the track. There was used in this patching or resurfacing 1,860 tons of hot mix binder and 600 tons of rock asphalt.

During the 1936 race there was very little skidding on the curves. The absence of wrecks during the qualifying period and the race prove the added safety which was built into the track.

Tight Form Joints Stop Cement Leakage

CAREFUL attention to methods of obtaining a smooth finish on concrete surfaces of the Colorado River aqueduct has brought into focus some of the difficulties involved and ways and means of overcoming them. Surprisingly small cracks in concrete forms, engineers of the Metropolitan Water District point out, are sufficient to cause leakage of cement that leaves a gravel pocket in the surface of the concrete rough enough to require patching after forms are removed. This is said to be particularly likely to occur where the effect of vibrators aids in building up pressures inside the forms. If joints can be made really tight the surface finish of concrete, as poured, can be materially improved.

Leakage is most likely to be troublesome, it is found, at two locations. These are (1) joints between the invert and the inside arch form and (2) joints in arch forms on curves where the insertion of gores is necessary.

The prescribed method of constructing conduit sections on the Colorado River aqueduct is to pour the invert first and when it has been cured thoroughly to place upon it the inside and outside forms for the arch. The desired tightness in the arch-invert joint (between well-cured concrete in the invert and fresh concrete in the arch) now is secured by setting the inside forms on a strip of sponge rubber about 3 in. wide and $\frac{3}{4}$ in. thick. This rubber strip is placed on the invert concrete, parallel to the conduit center line, along the surface against which the edge of the inside steel arch form fits. The weight of the forms on the rubber completely fills any unevenness of the surface where steel and concrete meet.

Joints in the arch forms have been sealed effectively before pouring concrete by use of a 2-in. friction tape very similar to that used by electricians but supplied at low cost by an arrangement with the manufacturer for a product designed expressly for this purpose. Its major requirements are that it have the necessary strength and adhesive quality to remain fastened to the steel inside forms while the concrete is being placed. In some cases when the forms are removed the tape adheres to the concrete but it is easily peeled off without any injurious effect on the inside finish.

These two methods of handling concrete forms more effectively have been developed and applied by engineers of the District in division 3.

MOSQUITO CONTROL ENGINEERING VII

Ending Malaria in New Mexico

With a WPA project sponsored by the state and supervised by the U. S. Public Health Service anopheline mosquito breeding places are being eliminated in the irrigated valley districts

By C. M. Adams,
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Malaria Control Program
Santa Fe, New Mexico

HOT WINDS whistled across the high mesa between Clovis and Santa Fe, carrying dust that veiled the New Mexico landscape in a soft brown haze on that September day a year ago. The left rear tire of my car had just gone flat, an old tin dipper handle thrust through it. To the discomfort of a scorching day was added the indignity of repairing a tire. After completing this job, I reached for my briefcase—I wanted to look once again at the order from the Surgeon General, assigning me to New Mexico on malaria control work. Surely someone had slipped a cog. But there it was, in black and white. I drove on, wondering how there could be any malaria when I hadn't seen enough water in which to wash my face, much less hatch a crop of mosquitoes.

Malaria problems of any importance in semi-arid New Mexico might seem preposterous. Like myself on that September day, others have not been introduced to the true New Mexico where centers of population are grouped around numerous rivers and streams affording water for irrigation. In these irrigated valleys lies the malaria problem.

How malaria was introduced

Malaria probably was brought to New Mexico from the miasmatic areas of old Mexico by some of the Spanish conquistadores. However, recorded history of malaria dates back only seventy years. Old settlers of Espanola Valley tell of violent attacks in the 70's that disrupted community life. In Dona Ana county, three hundred miles south, malaria was brought in by a regiment of negro soldiers shortly after the Civil War. In the San Juan basin, in the northwest, malaria followed discovery of oil and the influx of oil field workers from Texas and Oklahoma. The disease is endemic and on occasions epidemic in the entire Rio Grande basin and in the Mora and San Juan valleys. Actual blood tests show that many communities have as high as 30 per cent of the entire population infected.

There are three types of anophelene mosquitoes in New Mexico—the *punctipennis*, the *pseudo-punctipennis* and the *maculipennis*. All are biologically suitable for the transmission of malaria, but the *maculipennis* is the only actual vector, since it looks to the human race for its blood meal while the others prefer to feed on livestock and wild life. The *maculipennis* is a hardy species, surviving rigorous winters, and thriving in the cold, clear waters of seepage marshes and agricultural drainage canals. It carries on its activities with equal facility at 3,500 or 7,000 ft. altitudes.

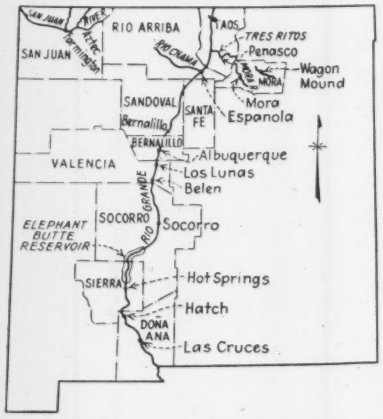


FIG. 1—LOCATION OF COUNTIES in New Mexico where the malaria control program is under way

The three main divisions of attack in the campaign against malaria are: (1) Location and cure of human carriers; (2) control of anophelene mosquitos through destruction of breeding places; (3) protection of humans from those mosquitoes which have defied control measures. It is in the second phase of this campaign that the engineer is most vitally concerned because elimination of breeding areas is a job of moving earth —digging ditches or filling swamps.

The director of the New Mexico Bureau of Public Health, visualized profitable employment for some of the great mass of unemployed taken over by relief agencies, and he arranged with the U. S. Public Health Service and the state WPA for a comprehensive program aimed at permanent elimination of breeding areas. The following briefly outlines the work that has been done to date and illustrates some typical problems.

Effective drainage

In general, malaria control drainage is confined to an area within flight range of human habitation, where mosquitoes can receive and transmit the malarial parasite. Swampy areas nearest larger centers of population are given first attention. Breeding areas at outer edges of the flight range radius of a mile and a half are reserved for the mopping-up activity.

Ditch digging, simple as it sounds, involves many factors that need careful consideration such as: most effective depth and bottom width, proper slope, and maximum gradient. The narrow bottom ditch has been adopted since it speeds up flow and thus becomes more nearly self-cleaning. Fast moving water makes it difficult for mosquito larvae to reach maturity, it inhibits growth of watercress and tules, and affords sufficient depth for *gambusia* minnows to flourish. Ditch banks are set on a minimum of 1:1 slope, though soil conditions sometimes make necessary more gentle slopes, such as 2:1 or 3:1. Setting up a uniform gradient is impossible because of wide variations in the fall of the valley floor. Where there is a choice, one percent is set as maximum; fall in excess is stepped down with checks. If the soil tends to erode, the fall is flattened out with checks to prevent undue washing. The spoil banks are wasted into adjoining low land or a wide berm is left in order to take weight off the ditch slopes.

Our young engineers found original answers to the problems of winter operation. In Mora County, ground froze 8 in. deep, but the engineer in charge kept men working by turning water from nearby hot springs over his job at night; in the morning the ground would be thawed and work progressed as usual. In San Juan county there was even deeper freezing—unless a spoil bank was moved the moment it came in contact with the top of the slope it was

frozen solid. Logs and brush from nearby thickets were piled on the right-of-way for the next day's excavation and on the frozen spoil bank and a workman would start a fire about midnight. By morning both the spoil bank and right-of-way were sufficiently thawed to carry on operations.

Preferring short ditches, well constructed, to many ditches that would not last through next winter, we have been generous in use of riprap, both rock and brush. Usually sufficient rock is closely available, either river boulders, *malpais* or volcanic rock, or sometimes stratified sandstone. Spanish-Americans are natural stone masons, a heritage of European ancestry kept keen in an environment where building timber is scarce, and they build beautiful rubble walls with any material at hand. One FERA ditch, riprapped with river boulders, has withstood two winters and two floods without losing a stone.

All curves in ditches are riprapped, sometimes only the outside wall, usually both. Every head wall for a flume or culvert is riprapped. Often it is necessary to riprap long stretches of straight ditch where washing might be serious.

In many places rivers flow through valleys on beds considerably higher than surrounding country. Many small swamps which are below seepage level must therefore be filled. Where dirt is handy they are filled level with surrounding country; where dirt is scarce they are filled only above the seepage line. The advantage of a fill job is its permanence without maintenance.

FIG. 2—CHECKS IN DITCHES on sloping ground are installed to flatten the grade and thus prevent erosion

Highway and reclamation engineers of New Mexico have been nature's chief imitators in the creation of mosquito breeding areas. When dirt was needed for a road or canal embankment it was borrowed from the nearest place with no thought for drainage. Thus many deep borrow pits were made. Eventually these fill with cool seepage water, support abundant aquatic vegetation and make ideal mosquito breeding places. Due to the usual scarcity of dirt close at hand, some of the pits can never be filled.

In regard to costs, it is of interest to report that while project estimates were set up for 80 cents per cu.yd. for hand excavation, the six months average was only 41 cents.

The by-products of a malaria control project are extremely valuable. They can be enumerated as:

(1) Highway improvement—By filling mosquito breeding borrow pits along rights-of-way, the highways are not only made safer, but the roadbeds are stronger and more pleasing to the eye.

(2) Water conservation—swampy areas drained into ditches and made available for growing crops yield much water once wasted through evaporation. Some of these swamp ditches, formerly having no outlet, now show flows varying between 0.2 and 3.3 sec.-ft. In New Mexico, water is life to the entire agricultural system; every gallon saved is a direct contribution to economic betterment.

(3) Land reclamation—Irrigated valleys have many acres of swamp heretofore useless; San Juan county alone has over 2,000 such acres. Drainage ditches and filling operations are reclaiming much of this land for production of food and forage. Since the economic life of New Mexico depends upon the number of irrigated acres, every one added increases permanent wealth.

(4) Employment of relief labor—Many of those who must look to the government for aid have had employment in localities where other projects were not feasible. Functioning on a high plane of efficiency, these men have felt pride in their work and have gained a measure of self-respect in honest labor.

(5) Flood control—Malaria drainage structures also serve as floodways, saving from periodic inundations many acres of valuable land.

After six months of operation, accomplishments may in a measure, be properly evaluated. Where once we had difficulty in obtaining rights-of-way

FIG. 3—TWO TYPES OF DITCH CONSTRUCTION adopted in New Mexico. At the left is a narrow bottom channel with 1:1 slope sides; riprap construction shown on the right provides a permanent, self-cleaning drain

for drainage ditches, we now find delegations of interested citizens applying to the Governor, the director of the WPA or the State Bureau of Public Health for aid in solving local malaria problems. Mail petitions for the project arrive in ever increasing numbers. This very healthful attitude encourages us in the further prosecution of the project. Protection from malaria carrying mosquitoes has now been given to approximately 80,000 New Mexico citizens.

Mosquito Abatement in Delaware

Under the direction of a Mosquito Control Commission an effective campaign, based on state-wide activity, has been conducted since 1933—Wild-life conservation aided by marsh ditching

By W. S. Corkran
Executive Officer and Engineer, Delaware Mosquito Control Commission, Lewes, Del.

UNDER THE DIRECTION of an unpaid commission of five members appointed in 1933, Delaware has attacked the problem of mosquito abatement as a statewide activity. With the aid of the Civilian Conservation Corps, four companies of which have been detailed to this work, a vigorous program of control has been instituted which has contributed to more healthful living conditions and has been of wide benefit to real estate development.

Conditions ideal for mosquito breeding are widespread in Delaware for not only is the entire eastern side of the state fringed with salt and brackish marshes, but a considerable area on the Chesapeake watershed consists of generally narrow swampy strips along tidal rivers. In order to provide an effective program for eradication the following three-phase plan was adopted: (1) Control of marsh breeding by ditching, dikes, tide and spill gates—this will eliminate about 50 per cent of the total breeding; (2) control of swamp breeding by clearing ditches and fish stocking—will eliminate 25 per cent of total breeding; (3) Control of domestic breeding by educating town officials and citizens generally—will eliminate about 25 per cent of the breeding.

Active program underway

Work was started on the first phase of the program in October 1933 and has continued diligently with CCC labor since that time. The second phase of control was inaugurated in 1935 with agriculaural drainage CCC forces operating directly under the U. S. Department of Agriculture. Since there is no law in Delaware giving mosquito control workers the right to enter upon and ditch or install drainage structures on private land it was necessary to obtain voluntary permission from owners. At first, some skepticism and difficulty were encountered but this problem has been gradually overcome by educational publicity.

The third or educational phase of the program has preceded concurrently with the other work. A traveling exhibit has been sent to county and municipal fairs and to every school. Illustrated lectures have also been given before civic organizations and clubs. A model mosquito control ordinance was prepared for municipal adoption, and several towns have already accepted it as part of their local laws (see Fig. 4).

Marsh control technique

In conducting control work on the marshes special technique and equipment have been developed. The basic essential, of course, is a system of ditches designed to carry off the normal and storm tides that periodically inundate these low-lying areas. In some places, such as the more or less landlocked marshes, a few tide gates and dikes may suffice to prevent the daily flood tides from submerging the area. It is seldom practical, however, to build these works large or extensive enough to exclude the high or unusual storm tides, hence, the main reliance must be on a well designed ditching system which will draw off the water within 5 days to a non-breeding level.

There is also to be considered the question of unnecessary overdraining to the point of damaging the wild life of our marshes (such as muskrats, fowl, etc.), which have an economic and social value. However, when it becomes a question of choosing between mosquitoes and wild life on those marshes within mosquito flight range of population centers then, of course, the human interests must predominate. We should not hinder the development of land or risk the health of an expanding population for the comparatively small profits derived from muskrat trapping or the questionable pleasure of gunners.

In most instances, it is possible to accomplish mosquito control without sacrificing or greatly changing wild life refuge areas. This is especially true along the coastal marshes where moon tides prevail, or around large bodies of water where wind-created tides fluctuate more or less periodically. In such places ditching systems can seldom "drain" the marshes to the point of damage from shrinkage. On the other hand they remove quickly the surplus water which floods the vegetation and causes it to "scald" by sun action, or to "burn" by salt water immersion. A good ditch system improves the circulation of water throughout the marshes, lowering the temperatures, relieving stagnation, and freshening the "pot-holes" and ponds that dot the surface and yet are too deep to be drained by the ditches. This circulation, besides permitting the larvae-eating fish (*Gambusia holbrooki, Fundulus heteroclitus,* F. *majalis,* F. *diaphanos*) to penetrate throughout the marsh, freshens the vegetation and induces the restoration of some species of aquatic and semi-aquatic plants that have been annihilated by stagnation and immersion. Furthermore, in the fresher water sections, ditches appear to be extremely beneficial to muskrat propagation by creating more runs of cleaner water and improving the vegetation which serves as food and also affords refuge from natural enemies. Also, the ice-covered ditches in winter, with their water courses beneath, enable the muskrats to find unfrozen food supplies.

Laying out and installing ditches and control works on marshes requires special methods, owing to the fact that these areas are usually flooded, are seldom more than twelve inches above normal high tides and footing is very insecure and treacherous. Before work is started a reconnaissance is necessary to determine the existing natural drainage, as any ditching plan should be an extension or improvement of this feature. Air views of the area, taken from about 10,000 ft. altitude and enlarged to 800 ft. per in. have been found most suitable on the Delaware work. These photos, supplementing the standard Geological Survey maps enlarged to the same scale, can then be superimposed on one another over a light source, and they afford the maximum of correct information obtainable as a starting point

with the minimum of effort in securing it.

The general plan of the ditching system on any particular marsh can be largely determined from a close study of the aerial photographs and maps. It will usually be necessary to visit the area and check the "naturals," and mark their changes of direction by temporary sight poles extending well above all vegetation. Next, the drainage plan is laid out on paper and this is checked and revised in the field by the company superintendent and engineer.

In general, a ditching plan consists of a grid layout of parallel and interconnected ditches spaced at 150 ft. intervals and perpendicular to the natural streams or an old or new main ditch. Where possible, emptying the laterals into navigable streams is avoided because of possible damage to the outlet ends from the "wash" of boat traffic, and the greater likelihood of ditches being blocked from dredging spoil.

The width of the ditches is determined mainly by the area to be drained and partly by the softness of the marsh soil. Where the marsh lacks sufficient natural firmness to maintain ditch widths and depths, or where the excavation of muskrats causes unusual softness, extra width must be allowed to attain the desired final cross-section. This last factor may increase the initial widths as much as 50 per cent. The ditches in Delaware are dug to a uniform depth of 20 in., and where located in the thick masses of marsh vegetation roots, the sides are cut vertically with a standard hay knife, thereby resulting in economy of excavation and preventing decrease in cross-section from vegetation sprouting on sloping sides. The widths vary in multiples of ten inches from 10 to 80 in.

Approximately 70 per cent of the Delaware ditches to date are 20 in. wide and 10 per cent are 10 in. wide. The high percentage of 20 in. widths is due to the proportionately high acreage of muskrat marshes in the area covered and to this width being so largely used for the ditches connecting 10 in. laterals. On most of our marshes, the lowest areas form a belt course from one to several hundred feet wide, adjacent to the high land, due probably to the deposit of silt and débris on the outer or water sides by flood and storm tides and by the "wash" of boats. This tendency toward unusual lowness near the high land must be planned for very carefully by including in the ditch system "band" ditches following the low spots. These "band" ditches also act as intersecting drains to collect the high land run-off and carry it away without permitting it to dissipate in the natural way, i.e., by seepage, through the marsh. They also serve as a connecting link between the dead-ends of the normal laterals and thus prevent blockages in a ditch which may cause stagnation and breeding in the area drained by that ditch.

Another condition frequently encountered is that of a marsh generally higher than average but with large low basins usually at considerable distance from main streams. As a rule these require dikes and tide gates to keep flood tides from filling them to a breeding level. Usually they are so overgrown with

FIG. 1—ARROW HEAD OUTLET FLUME for a marsh ditch through a sandy shore. The arrow head construction protects the outfall from silting and the wing walls on the shore prevent erosion.

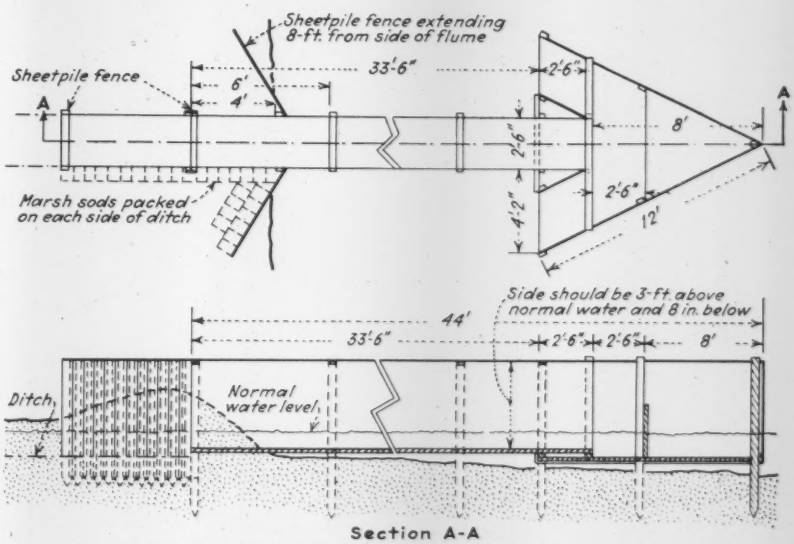


FIG. 2—CONSTRUCTION DETAILS of the standard outlet flume used in Delaware.

FIG. 3—SAND FENCE COREWALL CONSTRUCTION of rough slab lumber is the initial step in erecting a barrier to prevent the flooding of marshes behind sand dunes.

dense marsh vegetation that the small fish enemies cannot aid in destroying the larvae.

After the layout plan has been finally adopted, the company engineer, with a six-man layout crew, stakes it out. A control or base line is established for each marsh area. From this base, marked by high stakes, 4 ft. mason lath are set to work the ditches but spaced only as close together as necessary to find them readily. Light mountain transits, farm levels, stadia rods, and tapes comprise the principal items of equipment. All plotting is done in the field and the standard U. S. Engineer Corps tripod sketching kit is used for this purpose.

The digging of ditches is all done by hand. First, ropes are stretched along the line of lath stakes marking the ditch location and two men with standard hay knives (with reinforced handles) cut the ditch sides with a vertical up-and-down motion. Following this a "spader" and his working partner, the "hooker," cut and take out the sods. The former is equipped with a special 16-lb. T-handle ditching spade with which he chops off the sod and wrenches it loose and upward with a quick downward movement of the spade handle. The "hooker," using a standard potato hook, grasps the sod and swings it into uniform but staggered piles along the sides of the ditch. These men are followed by a "cleaner," who, with a hook, a shovel, or commercial clam rake, depending on the type of material being excavated, cleans the remaining débris out of the ditch and grades it to a uniform depth.

CCC labor very efficient

Two CCC companies starting in December 1933, augumented by one in August 1935 and one in October 1935, have dug a total of 8,985,620 lin.ft. of all width ditches up to June 1, 1936, in a net working time of 784,594 man-hours, plus 20,076 man-hours of CWA labor during the winter of 1933-34. This represents about 30 per cent of the marsh area of Delaware.

Converting this footage to the 10 in. ditch width basis, there has been constructed 19,498,530 lin.ft., or an average of 24.9 lin.ft. per man-hour, throughout the entire time regardless of weather, high tides, treacherous marshes, and other factors which have made this a difficult piece of work.

ORDINANCE FOR THE PREVENTION OF MOSQUITO BREEDING IN THE

.....

.....

Section 1.—It shall be unlawful within the (incorporated) limits of .... to have, keep, maintain, cause or permit any collection of standing or flowing water in which mosquitoes breed or are likely to breed, unless such collection of water is treated so as effectually to prevent such breeding.

Section 2.—Any collections of water considered by Section I of this ordinance shall be held to be those contained in ditches, pools, ponds, excavations, holes, depressions, open cess-pools, privy vaults, fountains, cisterns, tanks, shallow wells, barrels, troughs (except horse troughs in frequent use), urns, cans, boxes, bottles, tires, tubs, buckets, defective house roof gutters, tanks of flush closets or other similar water containers.

Section 3.—The method of treatment of any collections of water, that are specified in Section 2, directed toward the prevention of breeding of mosquitoes, shall be approved by the accredited health officer, and the Mosquito Control Commission of the State of Delaware, and may be any one or more of the following:

(a) Screening with wire netting of at least 16 or 18 meshes to the inch each way or with any other material which will effectually prevent the ingress or egress of mosquitoes.

(b) Complete emptying every four (4) days of unscreened containers, together with their thorough drying or cleaning.

(c) Using a larvicide approved and applied under the direction of the Mosquito Control Commission.

(d) Covering completely the surface of the water with kerosene, petroleum or paraffin oil once every seven (7) days.

(e) Cleaning and keeping sufficiently free of vegetable growth and other obstructions, and stocking with mosquito-destroying fish.

(f) Filling or draining to the satisfaction of the health officer and Mosquito Control Commission.

(g) Proper disposal, by removal or destruction, of tin cans, tin boxes, broken or empty bottles and similar articles likely to hold water.

Section 4.—The natural presence of mosquito larvae in standing or running water shall be evidence that mosquitoes are breeding there, and failure to prevent such breeding within three (3) days after notice by the health officer or Mosquito Control Commission, shall be deemed a violation of this ordinance.

Section 5.—Should the person or persons responsible for conditions giving rise to the breeding of mosquitoes fail or refuse to take necessary measures to prevent the same, within three (3) days after due notice has been given to them, the health officer, or other authority designated by the Mayor, is hereby authorized to do so, and all necessary cost incurred for this purpose shall be a charge against the property-owner or other person offending, as the case may be.

Section 6.—For the purpose of enforcing the provisions of this ordinance, the health offiier, or his duly accredited agent, acting under his authority, or the Inspectors of the Mosquito Control Commission, may at all reasonable times enter in and upon any premises within his jurisdiction; and any person or persons chargel with any of the duties imposed by this ordinance failing, within the time designated by this ordinance, or within the time stated in the notice of the health officer, as the case may be, to perform such duties, or to carry out the necessary measures to the satisfaction of the health officer, or the Mosquito Control Commission, shall be deemed guilty of a separate violation of this ordinance.

Section 7.—Any person who shall violate any provision of this ordinance shall on each conviction be subject to a fine of not less than One Dollar ($1.00) or more than Twenty-five Dollars ($25.00), in the discretion of the court.

Section 8.—All ordinances or parts of ordinances in conflict with this ordinance are hereby repealed, and this ordinance shall be in full force and effect..... days after its approval.

Adopted this .....day of.....
Approved this.....day of.....

FIG. 4—MODEL ORDINANCE drafted by the Delaware Mosquito Control Commission to aid municipalities in the adoption of a uniform local law to abate breeding places. Several towns have already adopted the ordinance.

Ditch excavation, totalling about 1,004,000 cu.yd. has been removed at an average rate of 1.28 cu.yd. per man-hour. This material weighs an average of 75 lb. per cu.ft., so therefore each man moved about 1.2 tons of material per hour.

The cost on the 10 in. basis, using CCC labor at $30 per month, has been 2c per lin.ft. This is based on an average of 40 work hours per week, or, deducting lunch and travel time to and from the work, a net of six hours out of the authorized eight per day. Field supervisory labor has been included at $1.20 per hour.

Research studies

In addition to carrying on a program of construction special attention has been devoted to research in order to develop basic data on certain fundamental factors affecting control work. These include: (1) tide and weather observations correlated with mosquito propagation; (2) marsh shrinkage and lateral seepage characteristics; (3) ditch flow, spacing and deterioration factors; (4) flume outlets through sandy shore lines; (5) improvements in standard structures and tools already adopted; (6) marsh flora—as indicative of soil characteristics and water table to aid in determinating ditching layouts and design; (7) development of ditching and cleaning machinery, (8) development of laws to protect mosquito control work; (9) development of better automatic traps for sampling mosquito density.

The mosquito control program in the areas where work has been carried on has been highly effective as indicated by the automatic trap records. In 1934 there was a 63 per cent reduction of mosquitoes and in 1935 there were 28 per cent less than the year previous. In addition, the drainage structures installed have improved marsh vegetation (including duck foods) and this has had a beneficial effect on wild-life conservation. Muskrats on some marshes have increased in number more than 30 per cent according to trappers. These facts indicate that mosquito control and wild-life conservation can be carried on satisfactorily in the same seacoast territory.

The Mosquito Control Commission in Delaware welcomes inspection of its work in the interests of promoting what today is undoubtedly a vital necessity in furthering the health, comfort and economic development of those living in mosquito-ridden areas.

The final articles of the mosquito control series will appear in next week's issue. One of these is by J. A. LePrince of the U. S. Public Health Service who discusses the malaria problem in the Mississippi Valley and the other is by Harold F. Gray, of the Alameda County Abatement District, who describes mosquito eradication in California.

Concrete Dispatching System Used at Grand Coulee Dam

Electric signal boards to transmit orders, automatic control for aggregate combinations and comprehensive system for checking form blocks all combine to speed progress

THE PROCESS of getting concrete into the right forms with minimum delay involves a complexity of operations at Grand Coulee Dam where upward of 7,000 cu.yd. is placed daily under very definite restrictions imposed by specifications. Because of the large quantity of concrete involved in the present contract (4,500,000 cu.yd.) it has been worth while to set up a rather elaborate system for communication and for operation of the concreting equipment. For example, a saving of 15 sec. in the mixer cycle can increase the output 670 cu.yd. per day (1,340 yd. for the two plants). With a premium of this sort on the saving of a few seconds in regular operations there is an inducement for every possible means to speed communication, facilitate accuracy and promptness in all operations and keep delays to an absolute minimum.

The Westmix plant was put in operation in December, 1935, and in the first seven months of operation placed about ¾ million cu.yd. This plant was described in *ENR*, Jan. 23, 1936, p. 119. The Eastmix plant, a duplicate installation on the east side of the river, was nearing completion in July, 1936, and in the second-step cofferdam which it is planned to unwater during the coming season of low flow in the Columbia, the concrete placing system complete in all respects will be an almost exact duplicate of that now in use in the west cofferdam.

In addition to the usual automatic control features which have been developed in recent years for large concrete mixing plants, operations at Grand Coulee are aided by a number of devices developed expressly for this job. With the common purpose of speedy progress, attention has been concentrated on facilitating operations in the mixer plant and in the forms where concrete is placed.

Three key men

In each mixer, plant control and operation centers in three men: the dispatcher, the batch operator and the mixer operator. With all parts of the organization functioning smoothly the dispatcher is the man who takes responsibility for continuity of effective operation. From his station he observes the movements of trains and cranes, gets reports by telephone from the placing foreman in each concrete block, tells the batch operator what particular mix to use and then sees that this batch is properly routed via high or low trestle to the particular form to which it is consigned.

Unlike the two other key men in the mixer plant, the dispatcher's station is located where it will give him a clear view of the dam as well. Also he has a complete set of controls and indicators. On information which he obtains by phone or by observation the dispatcher instructs the batch operator what particular combination of materials or mix is to be used in charging a certain mixer. Thereafter charging and mixing operations are in other hands but when the concrete is delivered from the mixers into buckets standing on a train, the dispatcher again is responsible for routing the batch and directs its delivery to the proper form.

This latter part of the dispatcher's function is facilitated by the use of markers bearing a color and a number. These are placed on all buckets whose contents are anything other than a capacity load of mass concrete. To facilitate this a tag for each of the several mixes (other than standard) is kept in a rack at the mixer plant and the proper tag is taken out and hung on the bucket as it receives its charge from the mixer. This facilitates such special cases as the handling of a bucket with only 1 or 2 yd. of grout which may be all that the form crew can broom out to advantage at one time under certain conditions. So that trainmen may know what flag to attach to a particular bucket of concrete, a trainman's board, in clear view of the concrete loading track, shows a signal to indicate the kind of mix being discharged by the mixer. This is an automatic control and the indication is predetermined when the batch operator sets his controls for the combination of materials.

The batch operator works entirely from instructions transmitted via signal board or by phone. He has no view of the work from his station; he is responsible for operation of the devices which get together the right materials in the right proportions for a designated batch. Most of this equipment is automatic, controlled by pushbuttons. After assembling materials on orders from the dispatcher the batch operator holds the batches ready for the mixers until the mixer operator signals that a mixer is ready for charging. Thereupon the batch operator discharges the batch into the mixer.

The mixer operator, in addition to his controls and signal board, also sees the trains beneath the mixer discharge. When

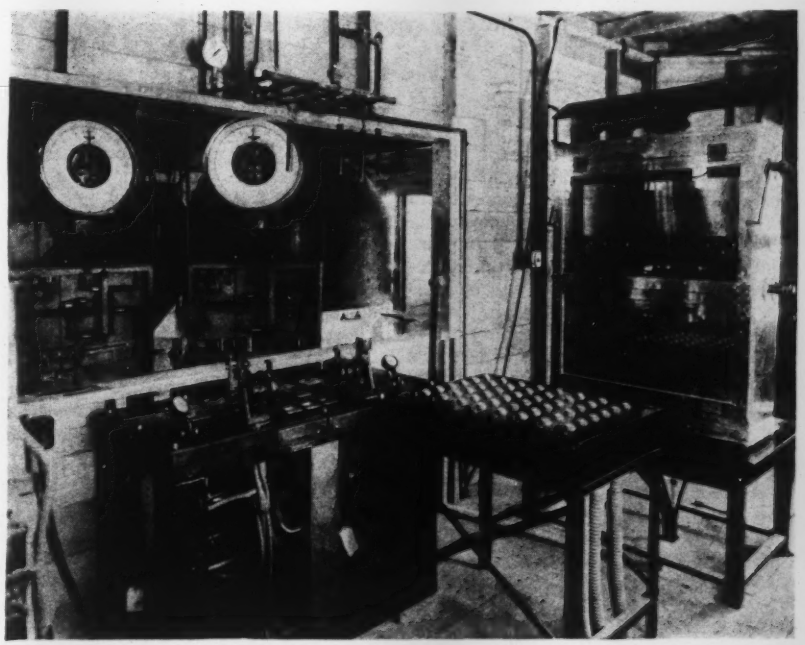


FIG. 1—BATCH OPERATOR'S CONTROL ROOM contains the control stand in center foreground, the dispatcher's signal board adjoining it on the right and at extreme right the batch recorder.

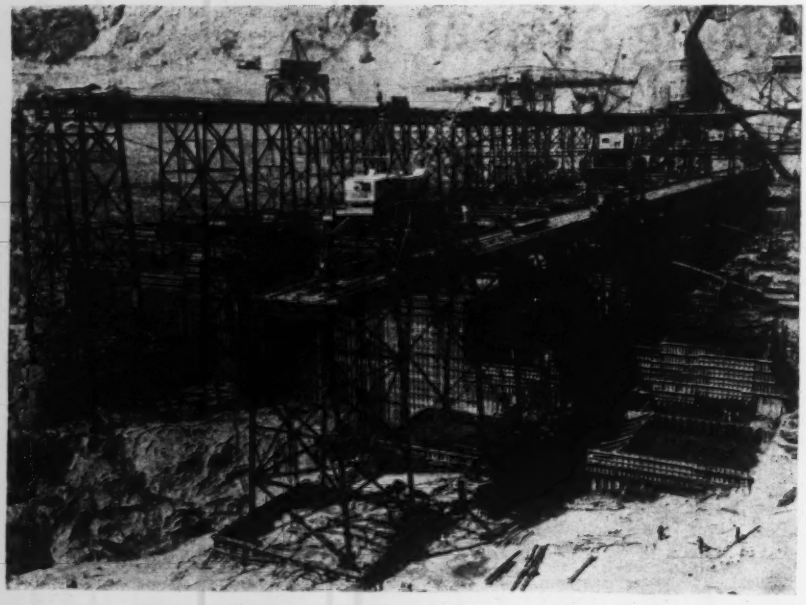


FIG. 2—CONCRETE PLACING OPERATIONS in west cofferdam. Westmix plant in upper right background supplies concrete to be placed by cranes on high- and low-level trestles.

a mixer is ready for a batch he signals the batch operator. After the mixer has been charged, the mixer operator puts it in operation and when mixing has been finished he discharges the concrete into the buckets on trains waiting below.

Thus the operations at each station are confined to certain definitely limited responsibilities and each man can concentrate on his own part in the important function of maintaining continuity of delivery. For the most part orders are transmitted by signals rather than by verbal communication. Typical of the time saving effected in this way is the indicator panel which orders a specified mix desired for a particular batch in any mixer. This indicator panel, installed in triplicate at the stations of dispatcher, batch operator and mixer operator, has five rows of lights with eight lights in each row, thus providing for five different mixes. This number comprises all the combinations now used on the dam. The eight lights in each row afford space for indicating any of the five mixes in any one of the four buckets on two four-bucket train-loads. Lights in the panels at batch operator and mixer operator stations are controlled by tumble switches thrown by the dispatcher. By use of corresponding switches the batch operator indicates when the dispatcher's orders have been carried out. Thus the indicator panel shows at a glance what mix is going through any particular mixer at a given time.

For communication between dispatcher, batch operator and mixer operator, supplementing the signal board, the original installation provided speaking tubes. After a little operating experience, the men wished to substitute telephones for the speaking tubes. This was done with the result that after a short trial period the men asked to have the speaking tubes restored and the telephones went out of service permanently. The conclusion is that unless the men will wear head sets, which these particular operators do not find it convenient to do, the speaking tube is more satisfactory than the telephone where there is so much noise as in the mixing plant.

FIG. 3—DUMPING A 4-CU.YD. BUCKET. Water pipes for cooling, laid on top of previous 5-ft. lift, appear at right. Crane signalman at left of bucket.

Routing and placing concrete

The dispatcher indicates whether a particular batch goes to the high or low trestle and the mixer operator routes it accordingly. The high-trestle trains receive their batches directly from the mixer. A batch for the low trestle goes into a skip which automatically dumps into a hopper over the loading point for the low-trestle trains.

In the west cofferdam area the high trestle has four cranes for delivering the 4-cu.yd. concrete buckets to the forms; the low trestle has three cranes for this purpose. A crane man in each form where concreting is going on has a telephone head set with which he is constantly in communication with the crane operator while the bucket is being delivered. The placing foreman in charge of each crew uses a phone connection maintained in each form for communication with the dispatcher. Under each placing foreman is a crew of eight men more commonly assigned as follows: five men using electric vibrators (a good many two-man vibrators are used), and three shovel men; one of the shovel men usually dumps the bucket.

Each pour constitutes a 5-ft. lift and in a block 50 ft. square (where no drifting of the buckets or other special work is required) the 465 cu.yd. in such a pour can be placed in about 7 hours. In some of the blocks it is not possible to lower the bucket directly to a position whence it can dump by gravity into all parts of the form block. Specifications permit a concrete spread after dumping of only 8 to 10 ft. Therefore for form blocks in which gravity delivery does not come within 10 ft. of all parts of the form a snatch block is put in and the buckets are pulled over by a winch in the crane above.

Ordinarily about five blocks are simultaneously receiving concrete. However, normal operation of the job calls for about 27 blocks to be cleaned up and formed if not actually released for pour by an inspector's O. K. Additional blocks ready to receive concrete are desirable in various parts of the dam to avoid unnecessarily long shifts in transferring operations from one block to another. The advantage in decreasing the distance of moves arises from the time involved in transferring the frequency changer (used for vibrators), the telephone connections and other equipment that has to be set in advance of pouring.

Form block schedule

Specifications require that at least 72 hours shall elapse between successive pours of the 5-ft. lifts. Adjacent blocks must not have a height difference of more than 25 ft. in an east and west direction (lengthwise of the dam) or 15 ft. in a north and south direction (transverse to dam axis). There are other limitations such as the restriction that cleaning off may not be done on a completed pour at a higher level than, and adjacent to, a block in process of receiving concrete.

Concrete is placed in form blocks of 26 different sizes in dam and power house. Blocks 50x50 ft. in plan are the standard, but the size ranges up to 50x63 ft. as a maximum and to a minimum of 25x44 ft. Determination of the pouring schedule is a rather complex problem where the various limitations and advantages affecting pouring extend over an area of about 500x1,200 ft. Responsibility for this is in the hands of a concrete schedule engineer who aids his records of the work with a small wooden model of the dam. A block of wood representing a 5-ft. lift is added to this model each time such a lift is completed in concrete on the dam itself. Thus a replica of the structure as completed is available as a visual aid to check the proposed progress schedule laid out.

In addition to the wooden model a wall board is maintained in which there is a pocket for each form block that is receiving concrete. In these pockets are kept two cards of different colors. One shows the time of starting and completing each pour and the elevation to which the concrete is or is to be completed. The other carries nothing but the release hour (allowing for the 72-hour period after final pouring) and this is not cleared until it has the O. K. of one of the inspectors representing the U. S. Bureau of Reclamation. Responsibility for securing the O. K. of inspectors is vested in a crew of "O. K. men." One of these men is assigned to the three areas into which the dam is divided for this purpose. Three O. K. men are on duty in each of the three 8-hour shifts; they clear through the concrete schedule engineer and their reports are not complete until entered on the schedule board.

The surface of each concrete pour is finished off to slope toward a predetermined low point (not on an outer edge) in which there is a 4-in. pipe riser leading to an 8-in. header at a lower level. These risers terminate just below the concrete surface in a sump about 1 ft. wide, formed to provide a convenient catch basin. A screen is placed over the open pipe end to catch any débris carried along with the wash water.

Assignment of crews to the particular form block in which they are to start work when they come on shift is made by the concrete superintendent. He posts on a blackboard at the cofferdam office the names of the foremen of the several crews together with the numbers of blocks to which they are assigned. Men coming on shift go first to this board to find where their crew is to work.

Grand Coulee Dam is being built for the U. S. Bureau of Reclamation, R. F. Walter, Denver, chief engineer; F. A. Banks, construction engineer at Grand Coulee Dam. The contract is held by the M. W. A. K. Co., George H. Atkinson, general manager; C. D. Riddle, chief engineer.

Six-Mile Trip by Boat Through Old Sewer

THE INTERIOR of a 6-mile length of the north outfall sewer at Los Angeles has just been inspected for the first time since its construction 12 years ago. The inspection was made by one of the city engineer's staff using a specially designed boat in which he floated down with the sewage stream during periods of low flow, between openings cut in the sewer for the purpose. Equipment included radio telephone, oxygen helmet, searchlight and camera. Every precaution had to be taken to avoid igniting explosive gases. As the outfall carries only sanitary sewage and is at the lower end of a system to which important contributary branches are 55 miles long, the sewage is exceedingly strong.

FOR SEWER INSPECTION a strange craft was built in Los Angeles and equipped with various devices for aiding a hazardous underground voyage.

The openings cut in the top of the sewer for access during the inspection were at thousand-foot intervals where this was feasible and thus the inspection was made in a series of relatively short trips. In one stretch, however, where the sewer was built as a tunnel, a minimum length of ½ mile between access points could not be avoided. Inspection began on July 4 and was completed July 19. An analysis of the findings, photographs of the sewer interior and other data now is being made.

The north outfall sewer is 10½ ft. high and 12 ft. 3 in. wide. The cross-section is semi-elliptical and the crown thickness is 15 in. of 1:3:5 unreinforced concrete. The lining is vitrified clay liner plates with narrow portland cement mortar joints. Some time ago it was discovered that during an unusually heavy rain when storm water inadvertently gained access to this sewer and caused it to flow under pressure, surface seepage was appearing at a point on the outfall where the earth cover was shallow. Test pits showed that at this point logitudinal cracks had developed in the sides of the crown as the result of eccentric sidehill loading. The damage was repaired by reinforced concrete blankets but the incident suggested the necessity of inspecting all parts of the outfall from the inside to see whether other portions had been damaged by earthquakes, by the effect of gases or from other causes.

Through each of the holes cut in the roof of the sewer for the inspection a framework was inserted to support a working platform near low-stage sewage level. This platform was used for access to the boat which was built for the express purpose of enabling the inspector to float down in the sewage stream, stopping to make careful examination or to photograph the walls wherever desirable. Some ventilation of the sewer resulted from natural draft through the access openings and in some instances this was supplemented by forced ventilation with the aid of portable blowers.

Ordinarily the inspections were made between the hours of 6 a.m. and 10 a.m. at which time the lowest stage of outfall flow occurs. From 800 to 6,000 lin.ft. of the outfall was inspected daily with some repeat inspections required in a few sections. The success in covering this 6-mile length of the lower end of the outfall has led to the decision to employ the same method for inspecting other portions of the city's sewers.

The boat used is a non-sinkable craft built specially for the purpose, and a steel cable to a winch on the surface was paid out so as to control its progress from manhole to manhole. The boat was moored in the sewer between inspection trips. The great quantities of hydrogen sulphide gas, gasoline vapors and other forms of combustible or poisonous gases in the sewer made it necessary for the inspector to use an oxygen helmet and to take every precaution against making any sparks that would cause an explosion. Earth induction telephones were used for two-way continuous conversation and reports to a stenographer above ground. This equipment made it possible to mark a spot on the surface immediately over the boat at any point in its journey, thus facilitating record of the location of any damage noted on the interior. An electric searchlight was used to illuminate the sewer interior for making photographs.

The inspections were made by Reuben F. Brown, assistant superintendent of sewer maintenance, under the direction of H. P. Cortelyou, deputy city engineer. Lloyd Aldrich is city engineer of Los Angeles.

Progressive Advance in Brewery Stockhouse Framing

S. E. Berkenblit
Architectural Engineer, Chicago

A STOCKHOUSE is that section of a brewery plant which is devoted to storage of beer for fermentation and ageing. It is essentially a refrigerated warehouse containing storage tanks. The design of these buildings has undergone progressive development in recent years culminating in some interesting new framing. Also the need to revamp old stockhouses for heavier tank loads has provided a fertile field for design ingenuity. The purpose of this article is to review some of these developments.

In pre-prohibition days vertical cylindrical tanks were in vogue and the structural problem for supporting these tanks was confined to designing a floor carrying fairly uniform loads. However, since capacity was proportional to the height of the tanks, it was necessary to design the floors for very heavy loads. For instance, a vertical tank 15 ft. high corresponded to a load of 1000 lb. per sq.ft.

A flat-slab concrete floor is suitable for this condition, and since the space between cylindrical tanks cannot well be utilized, concrete columns even if of large diameter can be used to advantage. Many of these old stockhouses were of reinforced concrete construction.

With the advent of horizontal cylindrical tanks in the stockhouse the structural problem has materially changed. As this type of tank is ordinarily supported on metal cradles a few feet apart resting directly on the floor, it is necessary to take care of concentrated loads. These concentrations are particularly heavy when double-tier tanks are used. In that case, the cradles of the upper tanks rest directly on the tanks below, and economy is effected not only from elimination of supports for the upper tanks but also from elimination of the entire floor for the upper tank level. Only a narrow cat walk is provided on the upper level for servicing the tanks.

The floor construction best suited for such tanks is usually steel beam and concrete slab supported on girders at the columns. Large buildings of multi-story construction and involving large investments have been built for supporting tanks in this manner.

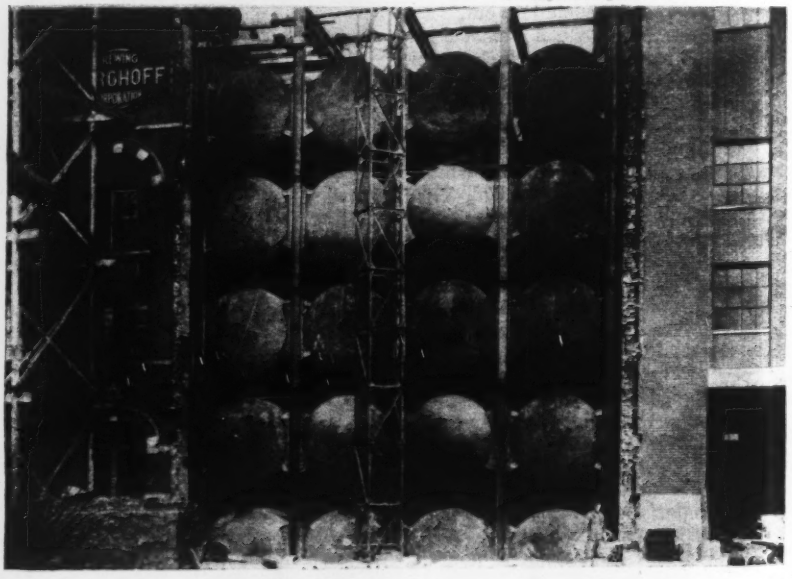
The most recent advance in the method of supporting horizontal tanks, with reference to economy of the supporting structure, is the utilization of the steel shell of the tank for carrying its own load. As the circular shell of steel has a high moment of inertia for the area of cross-section involved horizontal tanks may serve economically as beams for carrying very heavy loads. Longitudinal and circumferential stresses can be accurately determined, and the shell as well as the head designed for maximum combined stresses.

A most remarkable characteristic of this design is that it eliminates floors entirely, the tanks being supported at the ends on columns which also serve as the building framework. A walkway is provided at one end of the stock house, level with each horizontal row of tanks and communication is afforded by a stairway placed in this walkway.

The capital saving effected by elimination of floors results in a lower cost of building per barrel of storage capacity. A floorless building also permits maximum utilization of storage

FIG. 6—TANKS PERFORM DUAL ROLE of beer containers and horizontal framing in this modern stockhouse. Bracket supports shop-welded to the tanks are field-riveted to columns. Operation walkways are at far end of tanks. Frame is to be enclosed in brick and cork walls and concrete and cork roof.

Chicago Bridge & Iron Works Photo



A. O. Smith Corp. Photo

FIG. 2.—WELDED GLASS-LINED BEER STORAGE TANKS showing method of support used in stockhouse. The cast iron shoes rest on the transverse beam framing.

space as only about 2 ft. is required between tank tiers for fittings and hose lines. Other important savings result from operating economies, for it is easier to cool a one-room building than one broken up by floors. Also, only one set of coils is required as compared with a set for each floor in the older type building.

Directly connected with this method of tank support is the question of providing a tank lining that will not crack. Several such linings have been developed. Those of asphaltic composition are applied in the field while modern glass linings installed in the shop are available for tanks as large as 11½ ft. in diameter.

One of the latest designs of stockhouses in which the tanks serve also as framing replacing all beams and girders, is shown in Fig. 1. The columns supporting the tanks are 34 ft. apart longitudinally and 9½ ft. apart crosswise. The tanks are 8 ft. 5 in. in diameter by 34 ft. long and are supported by heavy plate and angle brackets riveted to the columns in the field and welded to the head of the tanks in the shop. The load on each bracket is 34,000 lb. in this installation.

Another type of tank support is illustrated in Fig. 2. Brackets welded to the tank heads rest on adjustable cast iron shoes which, in the building, are supported by the transverse beams framing between the columns. In this type of building both transverse and longitudinal beam framing is required but floors are eliminated.

A problem frequently encountered in old stockhouses is the demand for increasing strength of floor construction, to carry new heavy loads imposed by modern large capacity tanks. The principal difficulty in work of this kind results from the fact that the replacement of beams is often impossible, as neither beams nor columns are accessible due to the fact that the building is practically filled with tanks, and there is only a few feet clearance at the top where shoring or bracing can be used.

The writer recently had charge of strengthening an existing four-story stockhouse which exemplified the problems involved. The old framing consisted of 11 in. dia. pipe columns and girders made up of two I-beams side by side, and 9½ in. on centers. For strengthening the girders a welded bottom flange plate was the only feasible solution. Additional stiffness was secured by welding and bolting 4x4x⅜-in. angles between the I-beams at the point of maximum moment. The bolts were welded in place to minimize initial stresses in the welds and to decrease temperature stresses by breaking up the member into short units. Other girders in the same building but of longer span and subjected to much heavier moments were reinforced by 10-in. 21-lb. stubs, bolted and welded to the bottom flanges in place of the plate used elsewhere.

Water Service Survey Helpful in Marshalltown, Iowa

A SURVEY of water services in Marshalltown, Iowa, was discussed by H. V. Petersen, waterworks superintendent of that city, at the recent A.W.W.A. convention in Los Angeles, who reported that by having meter readers note the type of property served it was found that 95 per cent of all dwelling places consisted of single family houses. With a population of 18,451, the city last winter had about 4,628 families with an average of 3.99 persons per family.

As part of the survey, reports were turned in on the dwelling places not supplied by the city water service, from which it appeared that 92.3 per cent of all dwelling places in the city (single and multiple) had city service. As an aid in formulating a future water main extension program the location of dwelling places not on the city water system were marked on a map. From this it was learned that to supply 124 single-family houses located on streets where water mains had not been laid would require laying 4½ miles of new water main. If these mains were put in at an initial investment of $30,000 (cost of 6-in. water main extensions rated at $1.30 per foot), and assuming service was taken at every dwelling with an average yearly water bill of $10, the yearly income would be about 4 per cent the interest on the investment. However, previous experience has shown that not more than 10 per cent of these houses would take water service even if mains were laid. All factors considered, the water department concluded that it is not justified in laying more than ½ mile of new water main per year for the next ten years unless unknown factors appear.

The advantage of surveys of this sort was stressed as a means of enabling a water department to analyze the existing conditions and plans for future development.

Buenos Aires Sewers

Work is well under way on the construction of a sewerage system for the city of Buenos Aires. About $10,000,000 has already been expended, and a further expenditure of $23,350,000 has been authorized. The entire program is to be carried out within four years; it will constitute an important part of plans for civic improvement, which have included street widening, laying out of parks, and construction of many new buildings.

From Job and Office

Ice Used for Lowering Asphalt Tanks

THE UNIFORM melting characteristics of ice and its compressive strength proved of value in lowering asphalt tanks onto new foundations at Tampico, Mexico. In order to provide for gravity filling of hot asphalt into barrels, it was necessary for the Pierce Oil Co. to raise three 2,500 bbl. tanks, each weighing 40 tons, onto foundations 3 ft. above ground level.

The tanks were jacked up on cribbing and by the use of rollers were moved into position over the new foundation. Then to insure uniform lowering and do away with the necessity of using jacking lugs on the sides of the tanks, or of cutting jack holes in the concrete, it was decided to use blocks of ice to lower the tanks onto the foundations.

The compressive strength of the artificial ice used was computed at 7 tons per sq.ft., requiring 6 sq.ft. to support the entire tank. Blocks of ice 1-ft. thick were used at an air temperature of 80 deg. F. Approximately two hours were required to lower the tank, which settled uniformly over the entire circumference. As a factor of safety, and to prevent the tank from slipping off the foundation, the wood blocks were not all removed until the center of the bottom had come to rest on the concrete base.

The work was done under the direction of F. D. Smith, chief engineer for the Pierce Oil Co.

Two-Point Perspective Scale Aids in Making Drawings

By L. J. Smith

Head of the Department of Agricultural Engineering, State College of Washington

IN an effort to simplify the usual complicated procedure of laying out perspective drawings, a two-point perspective scale was developed by the author and has been used for three semesters by students in the Department of Agricultural Engineering at the State College of Washington. The scale makes it possible to draw the perspective directly on the paper somewhat in the same manner as making an isometric drawing, but using the customary vanishing points.

When laying out a drawing with the perspective scale, first draw the ground line $G+G$, and using any desired architectural scale, for example, the scale of $\frac{3}{8}$ in. equals 1 ft., draw the horizontal line $L+L$ 5 or 6 ft. above the ground line. At a point O on the ground line draw a perpendicular which will be the near corner of the object. The point C on the horizon line is the eye position, and from this point the vanishing point $V1$ is laid off at a distance equal to the length of the object to be drawn and the length $C+V2$ is three times the length of the object. Lines $O+V1$ and $O+V2$ are laid off representing the near end and side of the object. The length and depth of the building and locations of doors and windows are all measured from the point O, using the scale $\frac{3}{8}$ in. equals 1 ft. on the special perspective scale. On the rule there is a scale for measuring along the side and another for locating points along the near end of the drawing. It should be remembered that vertical distances are measured from the point O on the line $O+C$ by using the scale on the regular architects' rule.

The perspective scale speeds up and simplifies the development of perspective drawings. By using this scale it is possible to take any set of drawings of an object and draw its perspective directly on paper to the desired scale, regardless of what the scale of the original set of drawings may be. The scale is also helpful in drawing perspectives of objects without original drawings. By using the scale it is also possible to develop interiors of rooms using the two point method.

FIG. 1—SCALE RULE, developed to aid in laying out two-point perspective, is divided for measuring side and end dimensions.

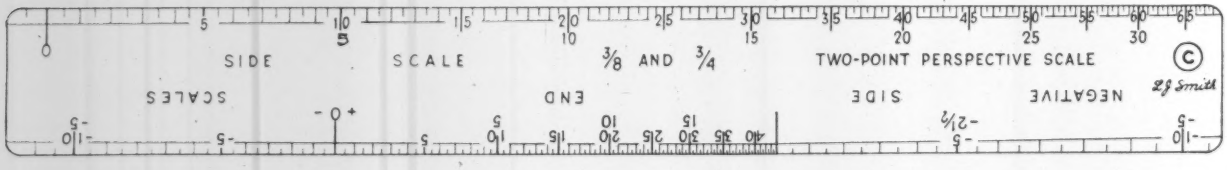
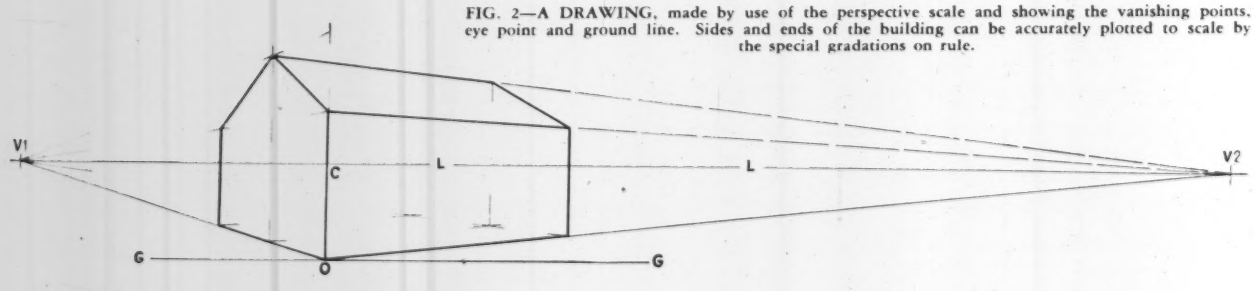


FIG. 2—A DRAWING, made by use of the perspective scale and showing the vanishing points, eye point and ground line. Sides and ends of the building can be accurately plotted to scale by the special gradations on rule.



Water Content in Concrete Varied to Suit Vibration

IN MAKING 42-in. vertical cast, vibrated reinforced-concrete pipe in 8-ft. lengths, with a wall thickness of 4½ in., for a Seattle sewer line, it was found desirable to vary the water-cement ratio of the concrete to compensate for the effects of vibration. That is, vibration caused water to work upward in the pipe forms, and hence concrete with a lesser slump was desirable near the top of each pipe section.

With a mix requiring 1.8 bbl. of cement per cu.yd., best results were obtained by using concrete with a 2½-in. slump at the bottom of the forms, lessening toward the top until the last batch had only about a ¾-in. slump. This water control maintained about the desired water-cement ratio throughout the pipe section.

For this pipe the minimum load re-

quired to produce a 1/100-in. crack was 1,500 lb. for each foot of diameter per linear-foot, or 42,000 lb. for the 8-ft. length when tested by the three-point bearing method. It was found that when concrete of uniform slump (2 or 2½ in.) was used throughout the pipe, this crack would appear at the top end of the pipe with as much as 4,000 lb. less load than at the bottom end. With pipe made with concrete of gradually diminishing slump, cracking was nearly uniform for the full length and could be produced only by heavier loading. With the desirable program, as outlined in the foregoing, external vibrators giving approximately 4,000 impulses per minute were used attached to the sheet-metal forms.

This work was done by The Concrete Pipe Co. for the city of Seattle. T. R. Beeman is city engineer.

Letters to the Editor

Reinforced Concrete Beams With End Thrust

Sir—In your issue of Aug. 6, 1936, p. 203 appears a criticism by Dean F. E. Turneaure of the writer's article in your issue of April 30, 1936, p. 632, concerning reinforced concrete beams with axial compression. Owing to lack of space it was necessary to omit a paragraph from the article which called attention to the difference between a column subject to bending and a beam with axial compression. In the latter case the unit stress in the reinforcement can be assumed the same as for a beam without axial load, and the section of the beam can be designed accordingly. This answers Dean Turneaure's objection to the writer's statement that this unit stress is not reduced by the axial load, as well as his objection regarding the consistency of the method presented for arch design.

As to the objection made to the development of Eq. (5), Dean Turneaure has missed the point there intended, which was to show that k for beams with axial compression cannot be determined in the commonly accepted way. If the objection made were valid that the value of p from Eq. (4) as used is incorrect in developing Eq. (5), then k, when derived in the usual way, is also incorrect in Eq. (4), where p is shown to depend only on k' and n. Dean Turneaure's objection here proves the writer's statement that the value of k derived in the usual way is incorrect for beams with axial compression. For these reasons his equations are also invalid. Eq. (5) was not used in developing design equations.

Error in assumption

Dean Turneaure makes the mistake of merely assuming that the plane of a cross-section before flexure remains a plane after flexure. It is possible to give extensive and rigid proof that such is not the case, and the illustration of a strut used by Dean Turneaure does not controvert this fact. The excessive depth of beam and deficiency in reinforcement resulting from the problem worked out by him is due to the value of k found by making erroneous assumptions. He also has not considered the necessity for using the axial load in a formula for the value of k'. The writer's method shows substantial economy in design.

HARRY E. ECKLES,
Assistant Highway Engineer,
Illinois Division of Highways.

Springfield, Ill.,
Aug. 11, 1936.

Elevated Tanks and Static Loads

Sir—The paper by H. M. Engle entitled "Elevated Tanks Strengthened after Earthquake Hazard Survey," (*ENR*, June 4, 1936, p. 807), presents the statement that "static analysis of structures such as those used to support elevated tanks applies quite accurately, and where intelligently followed in design will result in safe structures." This statement seems to have awakened criticism. In particular, Mr. H. A. Sweet (*ENR* July 16, 1936, p. 95) emphasizes the need for dynamic studies looking toward the probable occurrence of cumulative vibration produced by resonance between the natural period of vibration for the tower and the impressed period of vibration from the ground motion during an earthquake disturbance.

Careful studies required

This entire problem needs the most careful mathematical and laboratory studies, but, nevertheless, such studies must be digested carefully before they can be used as a basis for revision of standard specifications and of design procedure. It would be a simple matter to produce resonance on the shaking table, which might indicate a maximum deflection of 16 in. as mentioned by Mr. Sweet, but this is not evidence that resonance is a probable condition in the life of the structure.

After all, the problem to be solved is in the main one of probability. Cumulative vibration or resonance can only occur under a nicety of correlation between (1) the depth of water in the tank, (2) the stiffness or lack of stiffness designed into the structure, (3) the condition of repair as evidenced by the tightness of the diagonal bracing, and (4) a measured sequence of tuned vibrations of the earth. If, after thorough study, this combinaion of influences seems sufficiently probable, then the effect of resonance must be taken into account in design; otherwise a static acceleration loading should be chosen.

Nothing novel is being suggested here, but rather, a new application of a very old procedure. Snow falls on a bridge as well as on a roof but the engineer considers its combination with dead load, live load, impact, and wind to be so excessively improbable that he commonly neglects its consideration in design. Similarly, snowload stresses are ordinarily reduced by 50 per cent before they are combined with windload stresses for the design of a roof truss. The wind will probably, although not necessarily, blow most of the snow away.

Another similar case arises when one investigates the stresses in the floorbeam of a highway bridge. The live load is taken as two fully loaded trucks passing each other at the proper speed to produce a given percentage of impact with the rear wheels of both trucks placed exactly above the floorbeam. This is sufficiently improbable, but some specifications adopt the basic absurdity of adding the highly improbable requirement that the trucks must also crowd each other sidewise into the exact position for maximum moment in the floorbeam.

This is an excellent way to balance the books for the steel companies, but the improbabilities introduced approximate the improbability, in the new concept of physics, that the second law of thermodynamics may in some isolated instance be reversed. Many engineers recognize the absurdity involved and do not apply such specifications rigorously.

Until evidence to the contrary is available, it seems to the writer that common sense might point to the reasonable neglect in design of the extreme improbability that a water tank, which might pass through two or three earthquakes in its lifetime, would be subjective to cumulative vibration. It should be remembered that resonance is itself dependent upon the correlation of the four factors mentioned above and that earthquake motion is anything but a sequence of regular vibrations. On the other hand, the near certainty that the tower will have to resist horizontal acceleration forces necessitates its design for static horizontal loads.

L. E. GRINTER,
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Texas A & M College

College Station, Texas
July 22, 1936

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September 10, 1936

Cultivating Goodwill

TOO OFTEN the rights and conveniences of the public are ignored in the planning and conduct of construction operations. The work necessarily involves the noise, dirt and general disruption of services inseparable from wrecking, tearing up, and usurpation of the site and surrounding areas; but this inconvenience and annoyance can be greatly tempered by a little thought and care and by a change of attitude on the part of the constructors which would turn public exasperation into goodwill. Witness the praise and enthusiasm of residents of Evanston, Ill., who, looking forward to a year of torn-up streets in a citywide paving program, had the pleasant surprise of finding almost no inconvenience, because the contractor developed an ingenious paving plan that cleaned up two blocks a day. The citizens' dread of annoyance changed to pride in the project. Similar regard for the man in the street (P.S.—and the woman in the house) could profitably replace the "public-be-damned" attitude too often found in construction. Public goodwill is a valuable asset to the industry; it cannot be ignored with impunity.

With Public Support

THE CITY ENGINEER'S OFFICE in Seattle has been the scene of many political upheavals. In ten years seven men held this office, although at no time were there charges (or even the suspicion) of incompetence. Last fall the situation threatened to go even farther: it was proposed, obviously for political reasons, that the city engineer's duties be distributed to other departments and the office abolished; fortunately for Seattle, this plan was dropped. Now, apparently, the worm has turned. A charter amendment is being advocated by the chamber of commerce and engineering societies to relieve political pressure on the city engineer and the heads of three other departments (water, building, light) by giving these officials five-year terms, and making them subject to removal only for specified causes that are sustained after a public hearing before the city council. This plan in principle is to be commended as much as some of the earlier practices are to be condemned. Such moves, so obviously to the advantage of a city, need only adequate popular support to insure their success. No politician could save his face if he openly opposed a measure of this kind once it was widely understood.

Road Law Hazards

SESSIONS OF LEGISLATURES will be held in forty-two states during the coming winter. In highway legislation it is already indicated that accident prevention and motor-vehicle tax diversion will have special consideration. It is the business of the highway transport interests to see that the coming legislative action is not impulsive and emotional. This danger is particularly acute in respect to safety legislation; mounting deaths and injuries from motor vehicles (they promise a new high record in 1936) have made the public see red and have incited every extremist to put his wits to work on fancifully repressive laws that will set back highway development and make little real progress toward the fundamentals of travel safety. The unfortunate situation is that the transport expert and the road engineer have not settled in their own minds what had best be done. Neither can be proud of his record in perceiving the operating problem ahead and in putting his store of facts in shape to provide the solution that plainly would ultimately be demanded. Police records of accidents are rarely reliable determinations of fundamental causes; mere counts of dead and maimed (and these are all that legislators have to work with) point only to legislation that curtails road use, but does not assure safety. What transport needs is far greater extension of that use, and at the same time safe use. Drastic laws limiting road travel are the last thing that transport development can afford, and it should bring all its forces to bear to secure moderation in immediate legislation until the facts of accident causation are more clearly determined. Then let the highway traffic expert and road engineer get seriously at the task with which he has so far merely fumbled—that of determining highway safety and operating safeguards on which sound legislation can be based.

Better Use for the Money

AS DISCUSSED IN THIS COLUMN a week ago, the public-works movement to combat depression and promote recovery is dead, having received its final thrust by the subordination of a remnant of PWA activity to the relief-work system. But the PWA's decease is not to be wholly without a bit of show, it seems: something more than a million is to be spent in an occupational survey to determine what kinds of craftsmen are available on the relief rolls. Just what good will be obtained from this expenditure is not apparent, for shortage of skilled labor is developing in enough lines to show that the present reemployment problem lies elsewhere than in the field of occupational survey. Perhaps rehabilitation of deteriorated craft skill may be needed, but the survey as so far outlined is unlikely to reveal such a need. On the other hand there would be real value in a thorough census of unemployment, something that the relief authorities have sidestepped for more than two years against reiterated demand for it. Applied to such a census, the money that is to be spent would produce useful results.

Temporary Expedient

AFTER LONG DOING NOTHING EFFECTIVE about the evils of jurisdictional disputes in construction, the American Federation of Labor has at last taken steps to provide for the adjustment of such disputes. It has appointed an arbitrator who is to decide between crafts A and B when both claim that a certain operation is in their field—as when ironworkers and carpenters quarrel as to who shall set steel window frames in walls. The move is welcome; it is evidence of progressiveness in labor thinking, though it would be more convincing if it were not in all probability a mere defensive move in the factional warfare within the A.F.L. The plan has the highly commendable feature of providing that the

disputing unions are to continue at work pending decision of the dispute. On the other hand, past experience raises strong doubt whether the plan will work—previous attempts to eliminate jurisdictional disputes broke down as soon as a real fighting case came up. For this reason as well as because the arbitrator will be hampered by lack of knowledge, since he is not a construction man, the plan is unlikely to prove more than a temporary expedient. If neither the contractor nor the customer of construction depend on it, the plan will not eliminate the wasted expense of jurisdictional disputes and therefore has no cash value. Aside from this its significant characteristic is that it ignores the interests of the employer of construction labor, and proposes to make the decision wholly within the ranks of labor itself. In this respect it tends to break down the essential division of function between management and labor, which attempt also is not conducive to industrial peace and to reduction of excessive costs that hold back construction revival.

Fact Replaces Controversy

NOTABLE AMONG THE FIGHTING ISSUES of the west, the rivalry of claims to the upper Rio Grande waters has the distinction of involving several states, two separate major rivers, and our relations with Mexico, the latter because the flow of the Rio Grande is in part the joint property of Mexico and the United States. For many years the citizens of Colorado, New Mexico and Texas have been in dispute over this water. All three states need it for irrigation, which means life. But as neither the total supply, nor the consumption, nor available means of conserving and augmenting the supply, are accurately known, there is ready ground for controversy, which always thrives best where facts are least known.

The systematic study of facts reported last week (p. 331) is therefore a shortcut toward settlement of this sore interstate dispute. It is a model of the type of engineering determination needed in many parts of the country—in the west certainly, and probably also in many parts of the east, if the recent litigation over the Delaware and the Connecticut is indicative.

Chance of adjustment of the upper Rio Grande dispute through this study is particularly good because the international part of the problem was adjusted 30 years ago by a treaty grant of a definite water delivery to Mexico at El Paso and renunciation by our neighbor republic of all other claims to the river's waters down to Fort Quitman. That grant set a precedent of equitable action between nations and respect for long-existing human rights that will not only aid the upper river settlement but should exert strong influence on the separate and much more complex water problems of the lower river—from the canyon section to the Gulf. This problem too is certain to come to the front in the early future; and like that of the upper river, it depends first of all on determination of facts.

Studies of the kind now in progress in the region from the San Luis valley to El Paso need to be undertaken in other stream basins where water disputes exist. There has been too much quarreling, too much water stealing and Supreme Court litigation for the peace of western irrigated agriculture. Much of the trouble is due to the lack of an agency that can work impartially with the authorities of contending states to establish an acceptable basis of fact—something especially difficult to attain in the processes of prosecuting a suit in Washington. The mechanism of the National Resources Committee fortunately proved adaptable to the purpose of conducting this factfinding study. It may be hoped that the water-resources activity of this committee may be incorporated in a permanent body and given such governmental authority as will make it effective for continuing service in the difficult field of water claims.

Progress in Steel Design

A NEW design specification for steel for buildings has been issued by the American Institute of Steel Construction which provides for a basic unit stress of 20,000 lb. per sq.in. Recalling the animated arguments pro and con that accompanied the change from 16,000 to 18,000 lb. only a decade ago, one might suppose that the new specification would likewise engender some technical fireworks. It probably will not, for we are concerned with a better steel than was available in 1926; enough better in fact that the safety factor as measured by the ratio of ultimate strength to unit stress remains at 3.6. The advance to 20,000 lb. is thus a natural consequence of better steel manufacture, and the rolling mills deserve much of the credit for the economy that will result.

While the increased working stress will attract first interest in the new specification, greater significance attaches to some of its other provisions, which attempt to place steel design on a more scientific basis and keep it abreast of new knowledge. Thus, the marked increase in allowable rivet bearing values—40,000 and 32,000 for double- and single-shear rivets as against 30,000 and 24,000 formerly—should contribute measureably to more scientific joint design. With the unreasonably conservative bearing values that have obtained, it was practically impossible to make a joint fail in bearing; instead rivet shear controlled. Stated in another way bearing areas were so large as to be wasteful. The new specification should eliminate this waste.

Other new provisions look toward a more rational and probably less costly design for plate girders. By permitting the use of gross instead of net area in computing moments of inertia, the specification recognizes the results of experience which show that, rivet holes notwithstanding, failures seldom occur in the tension flange. Whether there is justification for disregarding them entirely—and using gross area—is a moot question. This subject is being studied in research at Swarthmore College and by the Navy Department at Washington, and there may be a compromise in the specification as it is published in its final form next year.

The specification puts forward a new criterion for beam web strength based on strength at the toe of the fillets rather than on column compressive strength of the web, in line with the results of recent tests. And it recognizes for the first time the strengethening effect of concrete encasement of steel members, albeit the recognition amounts to little more than a nod, since adequate test data are lacking. By and large the new specification is a distinct contribution to progress, and should exert an important influence both in crystallizing knowledge and stimulating research. In presenting it, the steel fabricators, represented by the A.I.S.C., have done the profession a distinct service.

CURRENT NEWS

Jurisdictional Referee For Building Unions

In a new effort to eliminate jurisdictional disputes among its various building trades unions, the American Federation of Labor has appointed as arbiter of such disputes Dr. John A. Lapp, now labor relations director of the Public Works Administration. Dr. Lapp will have full authority to settle controversies in which the unions involved are unable to reach an agreement. All nineteen unions in the building trades department have agreed to accept Dr. Lapp's decisions as final. Work on disputed projects will not be suspended during the period of deliberation, and attempts will be made to settle the matter by direct negotiation between the unions concerned before the referees's services are called upon. Dr. Lapp will keep his PWA post.

Dredging at Fort Peck Dam Sets New Record in August

Dredging records at Fort Peck dam were again shattered in August when 4,300,000 cu.yd. of material was pumped into the earth embankment by the four 28-in. dredges. The month's yardage amounted to 40 per cent more than the designed capacity of the dredging plant. Dredge *Missouri*, one of the four identical units, pumped 1,665,000 cu.yd. during the month. The August record is all the more remarkable because the *Jefferson* pumped the full time into the dike section of the dam against a static head of 240 ft. Hydraulic filling of the dike is about complete, and placing of rolled fill in the extreme end section is now under way. Total fill in the dam and dike at the end of August was 39,350,000 cu.yd., about 40 per cent of completion requirements.

Enlargement operations on tunnel No. 1 have been completed, and those on tunnels 2 and 3 are nearly complete. The Chicago Bridge & Iron Co. is fabricating the steel tube lining for the lower end of tunnel No. 1, to be used as a penstock in the future. Bartlett-Hayward Co. has started work on its contract for installation of the emergency tunnel control gates.

New Piers at San Francisco

The first new pier construction in San Francisco since 1931 will be started this month under a program approved by the California State Harbor Commission on Sept. 2. The project calls for replacement of piers 9 and 19 with modern concrete piers estimated to cost $1,500,000. This amount is to be made up of a PWA grant of $679,000 plus harbor bonds voted by the commission. This is a continuation of the program for developing San Francisco harbor which was halted during the depression.

Further Moves In TVA Suits

Texas and Alabama Companies Seek Supreme Court Decision—19 Utilities Abandon Alabama Suit

THE TEXAS Utilities Co. and the Alabama Power Co. have requested the U. S. Supreme Court to review a group of suits against PWA allotments to Plainview in Texas, and Florence, Sheffield, Tuscumbia, Decatur, Hartselle, Guntersville and Russellville in Alabama. Injunctions against these loans and grants were denied by the District of Columbia Supreme Court. The issues raised are similar to those involved in the Duke Power Co.'s suit against PWA, already on the Supreme Court docket, and question the legality of federal grants for municipal power plant construction.

The 19 utility companies which entered suit last May challenging the constitutionality of the entire TVA organization (*ENR*, June 4, 1936, p. 826; Aug. 27, 1936, p. 318), in the federal district court at Birmingham, Ala., have petitioned that court to dismiss the suit. The government had already asked its dismissal on the ground that no new question was raised which had not been settled by last spring's Supreme Court decision on the TVA. The Birmingham court dismissed the suit.

The utility companies will continue to press their suit, which was entered in the Tennessee chancery court at Knoxville at the same time that the Alabama case was brought. This suit was transferred in July to the federal district court in that city. TVA authorities have asked its dismissal on the ground that the Authority can only be sued in Alabama, but no ruling has yet been made on this contention.

Plans Approved For Michigan Bridge

The War Department has given approval to plans of the Michigan state highway department for an international bridge across the St. Clair river connecting Fort Huron, Mich. and Sarnia, Ont., Canada. Sinking of test borings to rock on both sides of the river was started under contract on Aug. 26.

The proposed bridge will be a steel cantilever with a horizontal clearance in the main span of 850 ft. and a vertical clearance of 152 ft. The bridge will carry a roadway 32 ft. wide and sidewalks 5 ft. wide. The total length, including approaches, will be 6,413 ft.

The total cost of the project including approaches is estimated at $3,000,000. Revenue bonds to be issued by the State Bridge Commission will furnish $1,900,000 of this sum. The remainder of the cost, covering approaches on the Michigan and Ontario sides, will be financed by the Michigan and Ontario highway departments.

All Bids Rejected On New York Subway

The New York Board of Transportation on Sept. 4 rejected all bids received for the construction of the second section of the Sixth Ave. subway, between 33rd and 40th Sts., and advertised for new bids to be opened Oct. 2. Seven bids were in the rejected lot, as follows: J. F. Cogan Co., $6,492,626; Park Contr. Corp., $8,231,273; George H. Flinn Corp., $8,346,325; Arthur A. Johnson-Necaro Co., Inc., $9,601,014; Spencer, White & Prentis, Inc., $9,871,008; Carleton Co., Inc., $9,902,554; and Underpinning & Foundation Co., Inc., $10,498,443.

Board of Transportation officials refused to state the reason for throwing out all of the bids. However, it is rumored that the low bidder, whose proposal was $1,739,000 below second bidder, was unable to obtain a surety bond, and that the Board did not desire to award the contract to the next bidder because of the wide spread between the two.

City of Pawtucket Buys Textile Plant

The Pawtucket, R. I., Industrial Commission, a municipal body, has purchased the Manville-Jenckes textile mill in that city from the Pawtucket Light & Power Co. The plant, which was valued at $3,000,000 was purchased for $55,000 cash and a $35,000 tax abatement. The city intends to set up a municipal textile mill which will give employment to unemployed textile workers in the city. Space in the plant will also be leased to new industries, and the power plant of the factory will be used to light the city streets and public buildings.

Board Will Study Extension Of California Water District

The board of directors of the Metropolitan Water District of Southern California is to give immedate consideration to the question of how much, if any, the boundaries of the district may be extended to include new territory, according to an announcement of August 31. The board recently announced that Colorado River aqueduct water will be made available only to cities or areas which are now or later may be admitted to the district. This announcement was made in response to an inquiry from officials of Orange County, Calif. A number of cities and areas have asked the district the terms on which Metropolitan aqueduct water will be available. Franklin Thomas, vice-chairman of the board has been appointed chairman of a special water problems committee to consider such applications. While some of the cities in the district appear to be willing to have a limited number of other cities ad-

Rudy Arnold Photo

PAVING BEGINS ON HENRY HUDSON BRIDGE IN NEW YORK

Following completion of the erection of the deck steel on the Henry Hudson Bridge at New York about the middle of last month, work was immediately begun on the roadway paving; in the above view, taken Sept. 3, forms on the north approach viaduct are shown in place. The bridge spans the Harlem River, with an 800 ft. hingeless steel arch, just above its confluence with the Hudson River. On the south it connects with Riverside Drive in Manhattan, while its north approach road crosses the Bronx, and Van Cortlandt Park to a junction with the Sawmill River Parkway in Westchester County. This notable arch, the longest of its type yet built, was described in *ENR*, Aug. 13, 1936, p. 232.

mitted to the district, other member cities have not expressed approval.

It is pointed out that all of the water to be brought in by the aqueduct will be made available to member cities on a pro rata basis. Annexation of new territory will result in present member cities giving up some of the water to which they are now entitled. To what extent they will be willing to give up any of these rights is the question that must be determined.

Areas requesting the terms upon which Metropolitan aqueduct water will be available include more than a score of Southern California cities and highly developed citrus lands, totaling approximately 400,000 acres and having a property value estimated at about $2,000,000,000. Under the water district's recently announced policy, these areas cannot secure Colorado River aqueduct water unless they are in the district.

Cities now in the Metropolitan Water District include Anaheim, Beverly Hills, Burbank, Compton, Fullerton, Glendale, Long Beach, Pasadena, San Marino, Santa Ana, Santa Monica, Torrence and Los Angeles.

Control of Personnel Given Oklahoma State Engineer

The attorney-general of Oklahoma has ruled that under the present highway commission law of Oklahoma the concurrence of the entire highway commission is not necessary for the employment and dismissal of highway department personnel.

According to the ruling, full control of personnel in the engineering division of the highway department is vested in the state engineer. Personnel of all other divisions of the department is controlled by the secretary of the state highway commission.

It has been the practice in the past in Oklahoma for the entire highway commission to pass on appointments and dismissals in the highway department.

Building Materials Dealers Investigated by FTC

The Federal Trade Commission is investigating charges of unfair trade practice against a number of organizations of building materials dealers. A complaint, ordering them to answer the charges, has been sent to six associations of lumbermen on the West Coast, and another to the Florida Building Material Institute of Orlando, Fla.

Both complaints charge the named organizations with attempting to restrain producers and manufacturers of building materials from selling to dealers not affiliated with the organization, forcing unaffiliated dealers to buy through organization members at a profit to the latter, denying membership to dealers refusing to support organization activities or competing with its members, and fixing schedules of uniform prices.

The Florida association has filed an answer with FTC denying that the Institute has ever attempted to fix prices or to interfere with the business of non-member dealers.

The California dealers have not yet filed their answer formally, but it is understood that their answer will maintain that the practices in question affect only intrastate commerce and are legal under the state price maintenance laws, which allow considerable latitude provided prices are kept at a reasonable level.

Maritime Meeting Of Canadian Group

Maritime section of Engineering Institute of Canada meets at St. John, N. B.

ONE of the most successful regional meetings which the Engineering Institute of Canada has held was the Maritime General Professional Meeting, held in Saint John, New Brunswick, Aug. 28 and 29. The meeting was organized by the Saint John branch of the Engineering Institute, in cooperation with the Association of Professional Engineers of New Brunswick. The meeting was fortunate in that Dr. E. A. Cleveland of Vancouver, President of the Institute, had come from the other side of the Dominion to attend and to preside at the leading social functions. J. R. Freeman, chairman of the Saint John branch of the Institute presided at the first technical session, and thereafter other officials of the Maritime engineering bodies acted as chairmen of the respective meetings.

Two technical sessions and the usual social functions were held. Two visits to engineering works had been arranged, the first being a tour of the new wharf construction at West Saint John and the second a trip to the Passamaquoddy tidal power project at Eastport, Maine.

New Brunswick Roads

The first of the technical papers was a description of recent highway construction work in New Brunswick, by R. E. Smith, of the provincial department of public works. The total road mileage is about 12,000 mi., of which 1,500 mi. are trunk roads. The present road work is concerned primarily with the 1,500 miles of trunk roads, all of which are to be converted from gravel surfaces to asphalt pavements. The program was authorized in 1930, the total sum allotted being $10,000,000. A 20 ft. pavement width has been adopted as standard. Careful location of culverts and the provision of a continuous drainage system of agricultural tile drain are the essentials of the subgrade work.

Construction Standards

The pavement is exclusively asphalt, using carefully graded local gravels as aggregate. A base course of 3 in. of bituminized gravel was standard in 1934, well rolled and then topped with a 1 in. sheet asphalt wearing surface, all hot mixed, a one day interval being allowed between rolling the base course and finishing. In 1936, practice was modified to a 4 in. base course, to be primed with asphalt, using ¼ to ½ imp. gal. to the square yard. This year, the use of a liquefier has been permitted, to enable a central batch plant to be used and the mixed material transported to different sites by rail. A softer grade of asphalt has also been used, to prevent cracking which developed in some of the earlier work. Cost figures given by Mr. Smith for grading and paving are as follows: 1934, surface coat of 1 in. sheet asphalt, $19,000 per mile; 1935, seal coat of about 40 lb./sq.yd., $17,000 per mile; 1936, including unusually heavy grading and a surface priming coat, $17,500 per mile. Of these figures, about

half is the cost of the asphalt pavement. In discussion, it developed that the estimated life for the present work was about 20 years.

The second paper presented was one on "The Fundamentals of Air Conditioning," by G. Lorne Wiggs, consulting engineer of Montreal. As explained by Mr. Wiggs, the paper presented no new data, but was a general survey of modern practice, and an attempt to clear away some of the prevalent misconceptions about air conditioning.

The third and final paper was presented by V. C. Chesnut, Senior Engineer to the Saint John Harbor Commissioners. It described the two million dollar reconstruction project now being carried out at West Saint John by the Foundation Company of Canada Ltd., main contractors. The work is notable in that for the first time in eastern Canada, a cylinder and surface slab type of wharf construction is being used. The 28-ft. tide, and the severe winter conditions encountered each year, make essential special attention to concrete work.

Contracts Cannot be Modified On Des Moines Bridge Jobs

A suggestion of Governor Herring of Iowa that the contracts on several Des Moines bridge projects on which work has been halted by labor trouble (*ENR*, July 30, 1936, page 176), be changed to incorporate the prevailing wage scale and correspondingly higher payment to the contractors, cannot be carried out, according to an opinion rendered by the state's attorney general.

The attorney general stated that the constitution of the state prohibits the highway commission from paying a contractor, after the contract has been entered into, extra compensation beyond that provided by the contract. Furthermore, the highway commission may not cancel a contract not in default, either with or without the consent of the contractor, for the purpose of re-letting it at increased cost. The state legislature has not granted the highway commission authority to require the prevailing wage scale in state highway contracts. The prevailing wage provision can be inserted in contracts on work involving federal money only by an action of the federal government, and on other contracts only by an action of the state legislature.

Fewer Types of Paving Brick

The revision of the simplified practice recommendation for vitrified paving brick, proposed last April, became effective June 30, 1936, according to an announcement by the division of simplified practice, National Bureau of Standards. The original recommendation, which became effective in 1922, provided for a reduction in the number of types from 66 to 11. The current revision, identified as "Simplified Practice Recommendation R1-36, Vitrified Paving Brick," leaves only four varieties. The new revision is based upon a survey, covering 98 per cent of the industry, made in 1935.

Fort Peck Rock Bids Rejected, Army Engineers to Open Quarry

All bids opened July 7 by the U. S. District Engineer, Col. T. B. Larkin, at Fort Peck, Mont., for furnishing from 730,000 to 800,000 cu.yd. of riprap to be used on the upstream face of Fort Peck dam, have been rejected, and the army engineers will obtain the required stone by day labor methods. Greater flexibility in the supply of stone on the hired labor basis, permitting placement of the riprap to be coordinated with dredging operations to the material advantage of the government, is the reason given for rejection of contractors' proposals. The army engineers will obtain the rock from a quarry to be opened up at Snake Butte, 14 miles south of Harlem, Mont., and about 150 miles from the dam. Contract for a 14-mile railroad connection with the Great Northern R.R., including a bridge over Milk River, has been awarded to the Tomlinson-Arkwright Const. Co., of Great Falls, Mont., for $296,732 on bids opened Aug. 25 at Fort Peck. The contractor commenced work Aug. 30.

Snake Butte, located on the Fort Belknap Indian Reservation, is a striking igneous formation of syenite, weighing 179 lb. per cu.ft. The Butte is 3 miles long, over a mile wide, and rises 300 ft. above the surrounding plains. The rock formation is columnar, the columns having a general hexagonal shape averaging 25 ft. in diameter.

The army engineers examined eight possible quarry sites, some more than 250 miles from Fort Peck. Specifications for the supplying of the riprap listed these eight sites as possible sources of material, but did not guarantee that any one of them would produce rock of required characteristics. It was up to the contractor to furnish rock of certain size, shape, density and hardness. The government refused to approve any source of stone prior to opening of bids. Stating the intent to use Snake Butte as the source of material, the R. Newton McDowell Co., of Kansas City, Mo., was apparent low bidder for supplying the stone at a cost of $1,440,000, exclusive of the cost to the government for railroad connections and freight.

Government Held Not Liable For Certain Flood Damages

The federal district court at Memphis held on Aug. 31 that the federal government is not responsible for damage incidental to its flood control work on the Mississippi.

Army engineers had built a 1,400-ft. dike extending out from the Arkansas shore. When land was washed away from the opposite shore, in Tipton County, Tenn., the owners of the land sued the federal government for damages.

The court held that the loss of land was due to natural erosion and was not directly caused by the construction of the dike.

The court, in its decision, did not seek to establish a general precedent, but held that a separate decision must be made in each case of this type as to whether the loss was directly caused by the new construction.

Bridge Failure in Virginia

Four men were killed in the failure of a bridge over Falling Creek on Route 10 in Virginia about five miles from Richmond. The bridge is a 52 ft. pin-connected Pony truss with a 12-ft. roadway, approached by a 27-ft. steel beam span; the pier and abutments are of concrete, and the floor is of wood.

Two trucks, carrying WPA workmen, were crossing the bridge at the time of the failure. The leading truck got across safely; the truck behind was caught on the falling span and collided with the abutment. The men killed were riding in the second truck.

Henry Shirley, Virginia commissioner of highways, attributes the failure to collision of the leading truck with the bridge. His investigation indicates that the leading truck struck the pipe rail on the approach span. It then destroyed the inclined end posts and one intermediate post of the right truss, while the rear end of the truck swung around and wrecked the left truss. The truck came off the bridge crosswise of the roadway, coming to rest on the pavement 20 ft. from the bridge end. The second truck came onto the falling span.

SOCIETY CALENDAR

PUBLIC WORKS CONGRESS, joint meeting, AMERICAN SOCIETY OF MUNICIPAL ENGINEERS AND INTERNATIONAL ASSOCIATION OF PUBLIC WORKS OFFICIALS, Toronto, Ont., Sept. 28-30.

CANADIAN INSTITUTE ON SEWAGE AND SANITATION, Royal York-Hotel, Toronto, Oct. 1-2, 1936.

INTERNATIONAL CONGRESS OF THE BUILDING OF STRUCTURES ABOVE GROUND, Berlin, Germany, Oct. 1-8.

INTERNATIONAL CONFERENCE ON STEEL CONSTRUCTION, Berlin, Germany, Oct. 2-7.

INTERNATIONAL ASSOCIATION FOR BRIDGE AND STRUCTURAL ENGINEERING, second congress, Berlin, Germany, Oct. 1-11.

NATIONAL SAFETY CONGRESS, annual meeting, Atlantic City, N. J., Oct. 5-9.

NATIONAL SOCIETY OF PROFESSIONAL ENGINEERS, annual convention, Washington, D. C., Oct. 12-13.

AMERICAN SOCIETY OF CIVIL ENGINEERS, fall meeting, Pittsburgh, Pa., Oct. 13-17.

NATIONAL COUNCIL OF STATE BOARDS OF ENGINEERING EXAMINERS, annual meeting, Knoxville, Tenn., Oct. 19-21.

AMERICAN WELDING SOCIETY, annual meeting, Cleveland, Ohio, Oct. 19-23.

AMERICAN PUBLIC HEALTH ASSOCIATION, annual meeting, New Orleans, La., Oct. 20-23.

AMERICAN WATER WORKS ASSOCIATION, ROCKY MOUNTAIN SECTION, Denver, Colo., Sept. 21-23.

NEW ENGLAND WATER WORKS ASSOCIATION, annual convention, New York, N. Y., Sept. 22-25.

AMERICAN WATER WORKS ASSOCIATION, NEW JERSEY SECTION; NEW JERSEY WATER WORKS ASSOCIATION; and the SOUTH JERSEY ASSOCIATION OF WATER SUPERINTENDENTS; joint meeting, Atlantic City, N. J., Oct. 23-24.

EXAMINATIONS for registration as Engineers, Land Surveyors and Architects will be held as follows:

IOWA, Examination for professional engineers and land surveyors, Des Moines, Iowa, Sept. 16-18.

NEW YORK STATE, examination for professional engineers and surveyors, Jan. 25-27, at Albany, Buffalo, New York City and Syracuse. Applications must be filed with the State Education Department at Albany before Nov. 1.

SETTLEMENT of the approach to the Huntington Ave. overpass in Boston is attributed to soft material underlying the fill.

Washington Highlight

By Paul Wooton

Construction to cost $10,936,233 is made possible by allotments totalling $4,855,142 for projects of the Public Works Administration. These allotments were approved by the President Sept. 8. The largest of the 140 projects calls for a loan of $385,000 and a grant of $315,000 for toll bridges at Deer Island, Maine. All of the money comes from old PWA assets. No allocations have been made, as yet, from the $300,000,000 earmarked for PWA in the 1936 act, except that the President approved an additional list of $7,000,000, of which some will come from the new appropriation.

Justice Owen J. Robert of the U. S. Supreme Court on September 1 granted the State of Colorado until December 15 in which to ask reconsideration of the Court's decision (*ENR*, June 4, 822) holding that Colorado must permit Wyoming to measure waters of the Laramie River used in Colorado.

Housing facilities, shops, and equipment at the unfinished Passamaquoddy tidal power project near Eastport, Maine, have been temporarily turned over to the National Youth Administration for use as a training school. Maintenance work at the project will still be a responsibility of the Army Engineers, but the school itself will be under NYA direction. Plans for the assembly of personnel are being rushed so that it can be opened within the next few weeks. Emphasis will be placed on technical and vocational training and production of materials for NYA projects.

Plans for a $1,500,000 improvement program affecting a number of public buildings in Washington, have been announced by the National Park Service, which will take charge of the work. Among the projects proposed will be the installation of fast elevators in the Veterans Administration building, where the wiring system will be changed from direct to alternating current, new elevators in the Farm Credit building, the old Land Office building, the old Patent Office building and the old Post Office. The last named trio of buildings will be changed to alternating current.

Failure of Bridge Approach

About 150 ft. of the approach to the new Huntington Ave. overpass in Boston settled on Aug. 29, two days before its scheduled opening. A maximum settlement of 6.5 ft. occurred, and sections of the fill have moved in a mass about 2 ft. toward the Muddy River, which runs beside the road. The failure is attributed to a flow toward the river of soft material underlying the fill.

No danger to the overpass itself is anticipated, as the settled stretch of roadway is about 400 ft. from the overpass.

Underground explorations had previously shown the existence of peat and soft material under the road. At that time it was planned to support the fill, which varies from 6 to 15 ft. in height, on a concrete platform and pile foundation. This plan was abandoned, however, when an earlier settlement led to the belief that the foundation had reached a stable position.

Commissioner Callahan of the Massachusetts Department of Public Works estimates the cost of repair at about $55,000.

Brief News

THE MASON-WALSH-ATKINSON-KIER company, contractors for the construction of Coulee dam, set a new concrete-placing record in August, averaging 6,470 cu.yds. a day for a total of 206,505 cu.yds. In June, 197,117 cu.yds. were placed, and in July, the previous high month, 200,230 cu.yds.

A CONTINUOUS OPENING through the excavation for the first operating unit of the Midtown Hudson tunnel from New York City to New Jersey was provided on Sept. 1 when a 700-ft. approach tunnel on the Jersey side was holed through. This tunnel is being drilled through rock under Kings Bluff by the Underpinning & Foundation Co. A structural steel lining with a concrete finish is being put in the tunnel under this same contract.

COMPLETION, ON SEPT. 5, of the deepening of the Livingston channel in the Detroit river at a cost of $3,250,000 is the last step in the $20,000,000 project for construction of a 24-ft. channel depth throughout the Great Lakes. The Livingston channel project has been under way since July, 1932. Four miles of the deepening work was done in the dry, with earth and rock cofferdams, the remaining two miles were blasted and dredged. The entire project was in rock.

JOSEPH M. BOEHM, a Buffalo contractor, has announced the formation of the Land Owners Rehabilitation Corporation, which plans to clear ten acres of the water-front slums of Buffalo and erect ten 8-story apartment buildings, containing 960 apartments, on the site. The buildings will cover 25 per cent of the project area and the balance will be made into a park. Maurice Deutsch of New York City is the architect on the project. The corporation is privately financed.

FERROMEX, the semi-official Mexican railroad building and operating company, has obtained a federal concession to construct and operate a railway 800 kilometers long that will traverse the southeastern states of Vera Cruz, Tabasco, Chaipas and Campeche, and which will follow a route different from that of the southeastern railroad which the same company is building to connect Mexico City with Campeche and Yucatan states. The railroad will have four branches. The estimated cost is about $25,000,000. Construction is to be pushed at the rate of 50 kilometers a year. Work will begin after the ministry of communications and public works has approved plans for the first ten kilometers.

Personals

FRED A. SALMON, assistant engineer for the Alabama state highway department, has resigned to accept a position with the Tennessee Tractor Co.

T. B. KIRKLAND, an architect connected with the Alabama state highway department has resigned to accept a position with the Resettlement Administration.

CHARLES D. BASSETT, an engineer for the War Department, who has been engaged on the construction of Passamaquoddy tidal project, has been transferred to the Mohawk Dam of the Muskingum Conservancy District.

COL. THOMAS H. JACKSON, who has been in charge of the Southern Pacific Division for the Corps of Engineers, has been assigned to duty in the office of the chief of engineers in Washington to write a special report on flood control.

JOHN KLORER, chief of the Louisiana State Board of Engineers, has been appointed planning and consulting engineer for the New Orleans Sewerage and Water Board. Before becoming chief of the state engineers, Mr. Klorer had served as chief of the Orleans Levee Board, as New Orleans commissioner of public property, and as city engineer of New Orleans.

WILLIAM G. GROVE, who has been principal engineer in charge of the bridge section of the Florida ship canal, has taken a posi-

tion in Mexico City with the United Engineers & Constructors of Philadelphia to design railroad bridges for the new line to be constructed by the Ferromex Railway.

F. A. DALE, formerly assistant construction engineer on Norris Dam, has been appointed project engineer for the Rural Electrification Division of the Porto Rico Reconstruction Administration, in charge of the design and construction of several hydroelectric projects.

Obituary

FRANK G. BLUE, 70, city engineer of Defiance, Ohio, died there Aug. 28.

EDWARD W. RYSTROM, project engineer with the Nebraska Department of Roads and Irrigation, died in Rockford, Ill. on Aug. 30.

CHARLES F. WHITE, a retired consulting engineer of Boston, Mass., died at Brookline, Mass., on Sept. 1, at the age of 80.

FRANCIS T. COLE, chief engineer of the Eastern Canada Steel Works, died Aug. 28, age 52.

CHARLES R. CORNWELL, assistant engineer of the Public Works Department of Poughkeepsie, N. Y., and formerly engineer of Dutchess County, N. Y., died on Sept. 1 in Poughkeepsie at the age of 73.

CONSTRUCTION STATISTICS FOR THE WEEK

ENGINEERING construction awards, representing a short week due to the Labor Day holiday, total $35,219,000 of which private is $7,844,000 and public $27,375,000. Of the public, $11,036,000 is federal and $16,339,000 state and municipal. This represents a gain over last week in federal construction due to a heavy increase in public building awards. Corresponding volume for a year ago is: total, $34,977,000; private, $3,966,000; public, $31,011,000; federal, $11,053,000; state, municipal, $19,958,000.

Both commercial and public building awards are higher this week, but all other classifications of work are lower than last week. The classification sub-totals are: public buildings, $13,534,000; commercial buildings, $5,752,000; industrial buildings, $1,516,000; highways, $9,049,000; bridges, $903,000; sewerage, $778,000; waterworks, $1,309,000; earthwork, drainage, $898,000; unclassified, $1,480,000.

The larger projects for the week include: 350 residences, International Business Machines Corp., Endicott, N. Y., by own forces, FHA financing, at Union, N. Y., $2,000,000; steam turbine generating plant and acquisition of present distribution system or construction of new distribution system subject to referendum, Ogden, Utah, $2,490,000; North Section, Julia Lathrop Homes, Public Works Administration, Division of Housing, Chicago, Ill., $2,097,000; South Section, $2,285,000; police court building, Washington, D. C., $1,312,000; superstructure, New Towne Court Housing Project, Public Works Administration, Division of Housing, Cambridge, Mass., $1,139,000; superstructure, College Court Housing Project, Public Works Administration, Division of Housing, Louisville, Ky., $552,000; 7.16 mi. Blue Ridge Parkway, Buncombe and McDowell Counties, Bureau of Public Roads, North Carolina, $586,000; highways, Minnesota, $1,454,000; Missouri, $676,000; Oregon, $582,000; New York, $1,255,000 and $552,000; substructure for bridge over 1st Narrows, entrance to Vancouver Harbor, First Narrows Bridge Co., Vancouver, B. C., Canada, $2,000,000; earth dam and concrete spillway on Alum fork of Saline River, Little Rock, Ark., $922,000; constructing a 9-mi., 12-in. natural gas pipe line and distribution system, booster station, etc., Texarkana, Tex., $755,000.

State and municipal bond sales total $4,530,000 and corporate security issues $1,500,000 plus the sale to RFC of $14,184,000 in bonds of Metropolitan Water District of Southern California.

CONTRACTS

(Thousands of Dollars)

	Weekly Average Sept. 1935	Prev. 4 Weeks	Week Sept. 10 1936
Federal Government	$9,191	$11,342	$11,036
State and Municipal	15,856	23,849	16,339
Total public	$25,047	$35,191	$27,375
Total private	3,663	9,007	7,844
Week's total	$28,710	$44,198	$35,219
Cumulative to date:			
1935	$964,540,000	1936	$1,613,236,000

NEW PRODUCTIVE CAPITAL

(Thousands of Dollars)

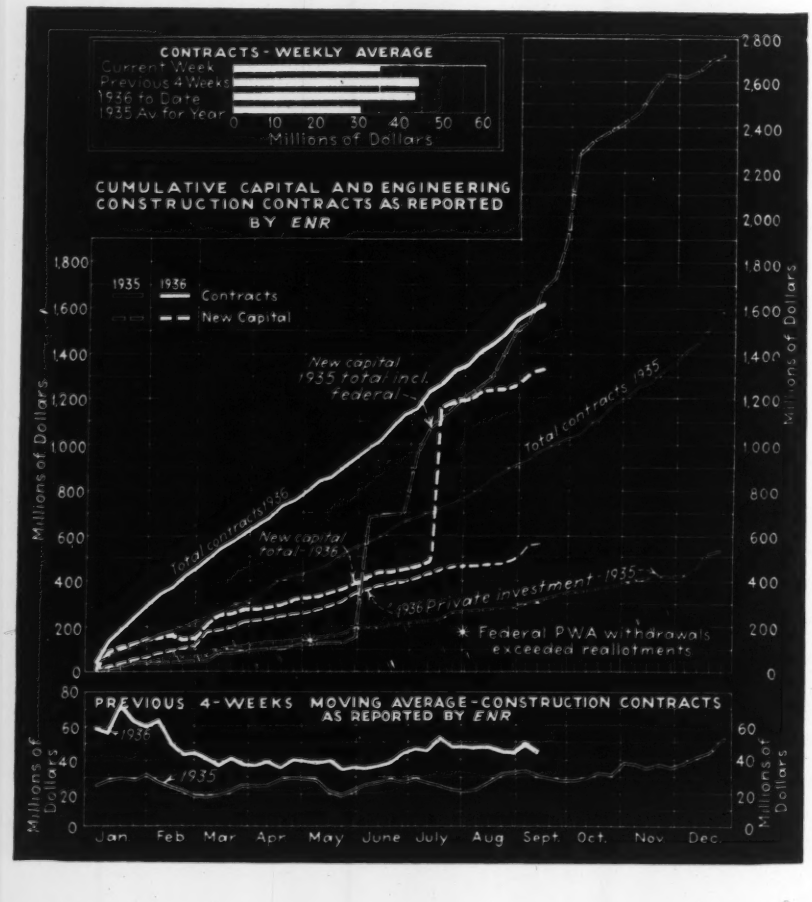
1936	Week Sept. 10	Cumulative
State and municipal	$4,530	$353,843
PWA non-federal	....	55,205
RFC loans	14,184	26,663
Corporate issues	1,500	200,377
PWA loans, Private	....	—1,665*
Total Non-Federal	$20,214	$634,423
Federal	....	691,237
Total new capital	$20,214	$1,325,660
Cumulative to date:		
1935	$1,667,133,000	1936	$1,325,660,000

*Bond sales in this classification exceed reallotments during current year.

Note: These figures include private bonds, and stocks sold for productive purposes; state and municipal bonds for construction; PWA loans and grants to states and municipalities. RFC direct purchase of bonds for "self liquidating" projects, and 25 per cent of WPA construction appropriations.

INDEX NUMBER

ENR Cost	1913 = 100	1926 = 100	ENR Volume	1913 = 100	1926 = 100
Sept., 1936	208.10	100.03	Aug., 1936	199	87
Aug., 1936	208.10	100.63	July, 1936	188	82
Sept., 1935	195.10	93.82	Aug., 1935	140	61
1935 (Av.)	195.22	93.84	1935 (Av.)	135	58
1934 (Av.)	198.10	95.23	1934 (Av.)	114	50
1933 (Av.)	170.18	81.80	1933 (Av.)	102	47


CONTRACTS - WEEKLY AVERAGE
Current Week
Previous 4 Weeks
1936 to Date
1935 Av for Year
0 10 20 30 40 50 60
Millions of Dollars
CUMULATIVE CAPITAL AND ENGINEERING CONSTRUCTION CONTRACTS AS REPORTED BY ENR
1935 1936
Contracts
New Capital
New capital 1935 total incl. federal
Total contracts 1935
Total contracts 1936
New capital total 1936
1936 Private investment
1935
* Federal PWA withdrawals exceeded reallotments
Millions of Dollars
PREVIOUS 4-WEEKS MOVING AVERAGE - CONSTRUCTION CONTRACTS AS REPORTED BY ENR
1936
1935
Jan Feb Mar Apr May June July Aug Sept Oct Nov Dec

Current Construction Unit Prices

Emergency Gates, Fort Peck Tunnels

CONTRACT for the completion of the emergency gate shafts at the four diversion tunnels for the Fort Peck dam in Montana was awarded in June, 1936, by the U. S. Division Engineer, Kansas City. The work involved includes the furnishing and installation of eight roller gates and operating machinery (two gates in each shaft), with all foundations and appurtenant works, eight bronze by-pass valves, one substation building and four buildings covering the shafts. The work must be completed by June 1, 1937, but the contractor will not have access to the foundations in tunnels No. 1 and 2 until Nov. 15, 1936, and in tunnels No. 3 and 4 until Jan. 1, 1937. The government will furnish mixed concrete to the contractor's containers, transportation of contractor's materials, unloading cranes, cement, sand and gravel other than for concrete unless for that to be desired to be mixed by the contractor, and all bituminous sealing solution for protection of shale and curing of concrete. Minimum wages stipulated are $1.20 for skilled labor; 50c. for common. Lt.-Col. Thomas B. Larkin is district engineer of the Fort Peck District.

Following is a unit bid tabulation of the three low bidders. (A) Bartlett Hayward Co., Baltimore, Md. (contract) $1,093,610; (B) Spillway Builders, Inc., Kansas City, Mo., $1,348,565; (C) Frazier-Davis Const. Co., St. Louis, $1,360,161.

FORT PECK TUNNEL EMERGENCY GATES

Item	Description	A	B	C
1.	Furnish, place joint filler—100 sq.ft.	$0.40	$1.00	$1.25
2.	Concrete, emergency shafts—5,200 cu. yd.	13.58	12.00	7.50
3.	Gunite coating—1,000 sq.ft.	1.26	1.00	1.25
4.	Drill grout holes—100 lin.ft.	.77	2.00	6.30
5.	Furnish, install grout pipe, connections—1,000 lb.	.185	.25	.40
6.	Pressure grouting—100 cu.ft.	5.57	3.00	6.30
7.	Excavation, buildings—300 cu.yd.	2.94	3.00	3.00
8.	Apply 1 coat sealing or waterpfg—100 square	5.84	1.50	2.00
9.	Concrete, buildings—1,530 cu.yd.	25.13	30.00	38.00
10.	Steel reinforcing, buildings—250,000 lb.	.046	.05	.06
11.	Structural steel, buildings—262,000 lb.	.063	.07	.073
12.	Emergency control shaft bldgs.—4, total	26,235	46,000	32,000
13.	One substation bldg.—total	3,826	10,000	2,400
14.	Bronze, gate guides—265,000 lb.	.315	.30	.45
15.	Structural steel, gate guides—237,000 lb.	.103	.25	.30
16.	Manganese bronze liner castings—748,000 lb.	.247	.30	.33
17.	Special manganese castings—306,000 lb.	.2775	.40	.37
18.	Steel liner plate—360,000 lb.	.119	.08	.14
19.	Vent pipes, complete—77,500 lb.	.088	.10	.08
20.	Steel reinforcing, complete—830,000 lb.	.047	.05	.06
21.	Misc. struct. steel—150,000 lb.	.085	.12	.12
22.	Emergency gates—8, each	28,700	30,000	30,000
23.	Operating machinery, gates—total	90,300	140,000	120,000
24.	Bronze by-pass valves—112,000 lb.	.308	.40	.40
25.	Electrical work, substation—total	16,875	25,000	20,000
26.	Electrical work, gates—total	66,200	85,000	85,000
27.	Electrical work, temporary distribution—total	4,695	20,000	4,000
28.	Manufacture, test, special manganese castings—875 lb.	2.00	1.00	2.00

Connecticut River Bridge, Middletown

SUBSTRUCTURE work on a new 3,420-ft. high-level highway bridge, 45 ft. wide and rising 93 ft. above the Connecticut River, to relieve the traffic congestion between Middletown and Portland, Conn., started in April, 1936, with the award of contract to Merritt-Chapman & Scott Corp. Bids for the superstructure were called at the same time as those for the foundations, and contract has been awarded to the low bidder, the Bethlehem Steel Co. The project is under the jurisdiction of Commissioner J. A. Macdonald and Bridge Engineer L. G. Sumner of the Connecticut State Highway Department. The schedule of operations calls for the completion of the approach piers by November 1, 1936, the entire substructure by March 1, 1937, and the superstructure by December 1, 1937, with minimum hourly wage rates stipulated of 85c. for skilled and 50c. for common labor. There will also be supplementary work covering approach fills, roadway and miscellaneous construction carried on simultaneously so that the entire project may be completed by the time the superstructure is ready for traffic.

The 1,200 ft. river span is carried on three main river piers. The original design called for two caissons, 20 to 28 ft. diameter for each pier, sunk 100 ft. to 120 ft. to rock. An alternative proposal for Atwell-Montee type caissons has been accepted. This type, described in *ENR*, July 11, 1935, was used on the new Federal post office building in New York City and consists of cylinders revolved to rock. This change in design requires the use of three clusters of eight caissons each for the river piers, ranging in diameter from 8½ ft. to 11½ ft. Steel bearing piles support the 26 approach piers. The Montee type caisson will replace piles on some of the approach piers. Railroad yards on the west bank necessitate the use of two 175-ft. continuous plate girder spans to avoid the use of additional piers in this area.

The accompanying tabulations list the unit prices, quantities and total bids on the substructure: (A) Merritt-Chapman & Scott Corp., New York (contract), $1,028,503; (B) P. T. Cox Contracting Co., New York, $1,065,080; (C) Dravo Contracting Co., Pittsburgh, $1,078,538. Superstructure: (D) Bethlehem Steel Co., (contract), $1,085,540; (E) Phoenix Bridge Co., $1,112,565; (F) American Bridge Co., $1,189,624.

CONNECTICUT RIVER BRIDGE, MIDDLETOWN

I—Substructure—Description	A	B	C
1. Clean and grub—total	$100.00	$5,000	$3,000
2. Earth excavation—100 cu.yd.	1.50	2.50	2.00
3. Brownstone fill excavation—8,400 cu.yd.	7.00	3.00	2.00
4. Rock excavation, river piers—350 cu.yd.	10.00	20.00	12.00
5. Excavation, west abutment—1,400 cu.yd.	3.00	3.00	3.00
6. Excavation, east viaduct—4,500 cu.yd.	3.00	3.50	3.00
7. Shaft excavation, river piers—4,900 cu.yd.	13.00	14.00	4.00
8. Caisson excavation—7,500 cu.yd.	4.50	10.00	6.00
9. Excavation, west viaduct—500 cu.yd.	3.00	3.50	2.00
10. Broken stone—350 tons	2.00	3.00	2.50
11. Concrete, west abutment—950 cu.yd.	11.40	10.00	15.00
12. Concrete, east viaduct—4,260 cu.yd.	12.40	13.00	20.00
13. Concrete, river piers—8,680 cu.yd.	9.40	8.00	25.00
14. Concrete, west viaduct—1,830 cu.yd.	12.15	12.00	15.00
15. Concrete, east abutment—900 cu.yd.	11.15	9.00	15.00
16. Concrete, caissons—7,900 cu.yd.	12.30	10.00	10.00
17. Deformed steel bars—1,140,000 lb.	.05	.04	.06
18. Cut stone, abutments—600 cu.yd.	60.00	55.00	58.00
19. Cut stone, piers—4,000 cu.yd.	50.00	52.00	43.00
20. Structural steel caissons—1,400,000 lb.	.073	.09	.06
21. Steel bearing piles—2,513,000 lb.	.025	.025	.026
22. Drive piles—40,250 lin.ft.	.37	.50	.30
23. Waterproof paint—6,000 sq.yd.	.15	.25	.25
24. Special wire fence—450 lin.ft.	2.00	3.00	1.00
25. Remove bldgs.—total	2,000	7,500	2,000
26. Soil pressure cells—40 each	30.00	50.00	30.00
27. Portland cement—40,000 bbl.	2.40	2.75	2.30

II—Superstructure—Description	D	E	F
1. Concrete, roadway floor—3,000 cu.yd.	$11.50	$11.90	$20.00
2. Concrete, sidewalks, curbs—1,100 cu.yd.	15.50	18.90	25.25
3. Concrete, steel grid floor—520 cu.yd.	11.00	6.20	12.00
4. Deformed steel bars—700,000 lb.	.04	.0470	.0536
5. Silicon steel, arch spans—3,050,000 lb.	.0692	.0655	.0724
6. Silicon steel, viaduct spans—2,100,000 lb.	.0489	.0522	.0555
7. Carbon steel, arch spans—4,500,000 lb.	.0592	.0570	.0596
8. Carbon steel, viaduct spans—4,100,000 lb.	.0410	.0448	.046
9. Eyebars and pins—1,440,000 lb.	.0745	.0857	.083
10. Suspender strands—63,000 lb.	.1460	.16	.1908
11. Suspender sockets—22,000 lb.	.2810	.2975	.1768
12. I beam LoK Floor steel—465,000 lb.	.0550	.0565	.0502
13. Unigrid floor steel—440,000 lb.	.06	.0620	.0551
14. Steel castings—260,000 lb.	.0750	.0710	.089
15. Phosphor bronze plates—1,000 lb.	.50	.3540	.33
16. Iron bridge rail—6,850 lin.ft.	5.25	5.10	4.87
17. Fence—265 lin.ft.	8.00	7.10	7.30
18. Leaders and gutters—600 lin.ft.	1.13	1.00	1.20
19. Portland cement—8,000 bbls.	2.29	2.55	2.66
20. Snow chutes—2 each	152.00	80.00	69.00

New York State Highways

FOUR contracts awarded early this summer reveal the trend of construction unit costs for paving, grade separation, culverts and bridges on New York State highways. The work involves 2.51 miles of bituminous macadam M.M. type 4, with one 248 ft. reinforced concrete bridge, one 21 ft. by 10 ft. box culvert, one three span stone faced concrete arch and two two span stone faced concrete arches at a total cost of $1,070,805.

The three low unit bids with the totals are compared for the four different projects in the following tabulation derived from the *Low Bidder* official publication of the New York State Highway Chapter A.G.C.

TOTAL BIDS OF THREE LOWEST BIDDERS

I—20 ft. M.M.4, N. Y. C. R.R. concrete approach—0.96 miles. Putnam County

A. John Arborio, Inc. Poughkeepsie, N. Y. (contract)	$88,40
B. Richards Bros. Inc., White Plains, N. Y.	89,16
C. Peter Mitchell, Inc., Greenwich, Conn	94,41

II—21 x 10 ft. Box, M.M.4 approach—0.48 miles. Delaware County

D. Mid-State Builders' Inc., Utica, N. Y. (contract)	$52,47
E. Tyne-Willey, Inc., Binghampton, N. Y.	55,96
F. Howes & Farrell, Inc., Sidney Center, N. Y.	56,41

III—248 ft. slab, M.M.4 approach—0.28 miles. Broome County

G. H. F. Stimm, Inc., Buffalo, N. Y. (contract)	$29,91
H. Tyne-Willey, Inc., Binghampton, N. Y.	31,20
J. E. V. Chappell, Binghampton, N. Y.	32,56

IV—60-64 ft. opt. col. concrete, 8-9 in. with arches—0.79 miles. Bron

K. D'Onfro Construction Co., Albany, N. Y. (contract)	$900,01
L. Chas. Shaffer & Son, Inc., New York City	924,174
M. Johnson, Drake & Piper, Inc. and Peter Mitchel, Inc., Freeport, N. Y.	961,96

NEW YORK STATE HIGHWAY CONSTRUCTION—SUMMER, 1936

Item	I Putnam County Concrete R.R. Approach Quan.	A	B	C	II Delaware County Box Culvert & Approaches Quan.	D	E	F	III Broome County Bridge & Approaches Quan.	G	H	J
1. Clear & grub—total	.....	$650.00	$650.00	$700.00	.....	$1,000	$1,000	$1,100	.....	$110.00	$100.00	$100.00
2. Excavation, common—cu.yd.	83,000	.45	.40	.42	40,000	.20	.30	.375	12,200	.25	.40	.35
3. Trench, culvert, bridge excav.—cu.yd.	1,700	1.50	1.50	1.50	1,300	.75	1.00	1.50	1,250	1.00	1.00	1.50
4. Trim shoulders—l.f.r.d.	5,490	.20	.20	.15	2,600	.22	.20	.20	1,480	.10	.20	.20
5. Prepare fine grade—sq.yd.	12,410	.10	.20	.15	5,750	.20	.20	.15	3,400	.10	.20	.20
6. Pipe underdr. opt. 6 in.—lin.ft.	2,000	.25	.30	.30	500	.25	.25	.27	100	.25	.25	.25
7 C. I. or spec. RCP, opt. 18 in.—lin.ft.	40	2.00	2.00	3.00	.....	.....	.....	.....	.....	.....	.....	.....
8. C. I. or spec. RCP, opt. 24 in.—lin.ft.	264	3.00	4.00	4.00	.....	.....	.....	.....	.....	.....	.....	.....
9. C. I. or spec. RCP, opt. 36 in.—lin.ft.	140	8.00	8.00	9.00	60	9.00	9.00	12.00	.....	.....	.....	.....
10. Portland cement—bbl.	900	2.50	2.85	2.65	1,326	2.45	3.00	2.90	700	2.80	2.80	2.80
11. Natural cement—bbl.	285	2.00	2.16	2.00	685	1.90	2.25	2.20	250	2.20	2.20	2.20
12. Structure concrete—cu.yd.	320	15.00	15.00	15.00	1,008	16.00	14.00	12.60	60	16.00	15.00	18.00
13. Concrete, cl. 1—cu.yd.	35	18.00	18.00	18.00	6	20.00	20.00	20.00	.....	.....	.....	.....
14. Concrete, cl. 2—cu.yd.	210	12.00	12.00	12.00	5	16.50	15.00	16.50	620	12.00	11.00	13.00
15 Stone backing, loose—cu.yd.	120	3.80	2.00	3.50	130	3.30	4.50	4.50	80	4.00	4.00	4.00
16. Struct. bar reinforcing—lb.	40,000	.05	.05	.045	110,500	.04	.05	.046	7,600	.06	.06	.06
17. Misc. iron, steel—lb.	540	.10	.10	.10	.....	.....	.....	.....	.....	.....	.....	.....
18. Cable guard railing—lin.ft.	5,000	.75	.90	.95	780	.75	1.25	.90	2,300	.82	1.00	1.00
19. Guide posts—each.	12	2.50	2.50	2.50	18	2.50	2.50	2.50	.....	.....	.....	.....
20. Fdt. course, R.O.B. gravel—cu.yd.	1,500	1.00	.50	1.00	1,440	1.60	1.00	1.00	850	1.00	1.25	1.00
21. Bottom course, broken stone—cu.yd.	1,725	4.00	4.75	5.50	480	5.50	5.90	5.40	280	5.00	6.00	5.50
22. Top course, bit. mac. MM, type 4—sq.yd.	12,410	1.00	1.15	1.35	5,750	1.15	1.00	.90	3,400	.90	1.00	1.10
23. Bit. mat. waterproofing—gal.	180	.75	.75	.75	330	.50	.50	.50	.....	.....	.....	.....
24. Maint. traffic for bit mac—l.f.r.d.	1,400	.20	.20	.10	1,050	.15	.20	.10	1,500	.10	.20	.20
25. Protect traffic—total	.....	150.00	150.00	150.00	.....	250.00	250.00	275.00	.....	275.00	250.00	250.00
26. Permanent sheeting, bracing—M.B.M.	2.4	70.00	70.00	70.00	.....	.....	.....	.....	.....	.....	.....	.....
27. Broken stone, L.M.2—cu.yd.	33	3.35	3.00	3.35	.....	.....	.....	.....	.....	.....	.....	.....
28. Broken stone, L.M.4—cu.yd.	395	3.35	3.00	3.00	.....	.....	.....	.....	.....	.....	.....	.....
29. Concrete gutter—sq.yd.	894	1.60	1.50	1.30	.....	.....	.....	.....	.....	.....	.....	.....
30. Concrete R & W markers—each.	60	2.50	2.00	2.50	12	4.00	4.00	1.50	12	2.00	4.00	4.00
31. Timber, lumber—M.B.M.	0.5	60.00	60.00	60.00	1	45.00	60.00	60.00	1	60.00	60.00	60.00
32. Explosives, embankment—lb.	5,500	.25	.30	.30	.....	.....	.....	.....	.....	.....	.....	.....
33. Pipe underdrain, opt. 4 in.—lin.ft.	.....	.....	.....	.....	90	.25	.25	.25	180	.20	.25	.25
34. Maintain traffic, culverts—total	.....	.....	.....	.....	.....	75.00	75.00	80.00	.....	110.00	100.00	100.00
35. Dry riprap—cu.yd.	.....	.....	.....	.....	150	4.00	4.00	4.00	70	3.00	4.00	4.00
36. Cofferdams, pump, bail, drain—total	.....	.....	.....	.....	.....	330.00	300.00	300.00	.....	550.00	500.00	500.00
37. Screened gravel, loose—cu.yd.	.....	.....	.....	.....	250	2.00	2.50	2.50	40	2.00	2.00	1.25
38. Stone masonry parapets—cu.yd.	.....	.....	.....	.....	.....	.....	.....	.....	6	30.00	35.00	38.50
39. Dismantle, store temp. bridge—total	.....	.....	.....	.....	.....	.....	.....	.....	.....	110.00	100.00	100.00
40. Timber piles—lin.ft.	.....	.....	.....	.....	.....	.....	.....	.....	4,500	.90	.50	.50
41. Pile driver equipment—total	.....	.....	.....	.....	.....	.....	.....	.....	.....	275.00	250.00	250.00

Item	IV Henry Hudson Parkway Grade Sep. K	L	M
1. Clear & grub—total	$2,000	$2,200	$2,200
2. Excavation, common—136,000 cu.yd.	1.49	1.55	1.65
3. Trench, shoulder, bridge excav.—25,700 cu.yd.	2.30	2.64	2.64
4. Trim shoulders, slopes—total	1,000	1,100	1,100
5. Prepare fine grade—67,000 sq.yd.	.20	.15	.22
6. Sewer pipe, opt. 12 in.—1,000 lin.ft.	1.25	1.10	1.00
7. Sewer pipe, opt. 15 in.—280 lin.ft.	1.50	1.25	1.40
8. Sewer pipe, opt. 18 in.—32 lin.ft.	1.75	1.75	1.90
9. Pipe underdr. opt. 4 in.—3,100 lin.ft.	.30	.20	.30
10. Pipe underdr. opt. 6 in.—7,700 lin.ft.	.40	.30	.35
11. C. I. pipe, 8 in.—60 lin.ft.	1.60	1.60	1.25
12. C. I. pipe, 16 in.—370 lin.ft.	2.20	2.20	2.10
13. C. I. or spec. RCP, opt. 15 in.—5,550 lin.ft.	2.00	1.50	1.80
14. C. I. or spec. RCP, opt. 18 in.—1,130 lin.ft.	2.60	1.65	2.10
15. C. I. or spec. RCP, opt. 24 in.—420 lin.ft.	4.30	3.00	3.50
16. C. I. or spec. RCP, opt. 30 in.—68 lin.ft.	7.30	4.10	5.50
17. Spec. reinf.-con. pipe, 30 in.—260 lin.ft.	5.20	4.10	5.50
18. Portland cement—12,960 bbl.	2.65	2.40	2.40
19. Natural cement—4,220 bbl.	2.10	1.90	2.00
20. Structure concrete—2,910 cu.yd.	16.00	17.00	16.00
21. Concrete, cl. 1—490 cu.yd.	16.00	17.00	17.00
22. Concrete, cl. 2—3,730 cu.yd.	14.00	16.00	16.00
23. Dimension masonry—490 cu.yd.	156.00	160.00	129.00
24. Stone masonry—910 cu.yd.	50.00	50.00	45.50
25. Stone masonry, dry—135 cu.yd.	15.00	15.00	15.00
26. Stone backing, loose—1,000 cu.yd.	3.20	3.00	3.50
27. Steel fabric, pavement—1,420 sq.yd.	.25	.30	.30
28. Reinforcing steel—430,500 lb.	.045	.045	.045
29. Misc. iron steel—106,500 lb.	.08	.07	.08
30. Bot. course, broken stone—850 cu.yd.	4.00	4.70	4.90
31. Colored cement pavement—205 cu.yd.	8.00	8.00	8.00
32. Top course, bit. Mac. M.M.3—725 ton	8.00	8.00	9.00
33. Bit. mac. waterproofing—1,115 gal.	.60	.40	.50
63. Membr. waterproofing—1,950 sq.yd.	1.20	.75	1.25
64. Bit. mac. T surfacing—1,470 gal.	.16	.16	.16
64. Maintain traffic, culverts—total	500.00	550.00	550.00
66. Maintain traffic—22,300 lin.ft.	.15	.15	.01
67. Protect traffic—total	1,000	1,100	1,100
68. Steel sheet piles—11,000 lb.	$0.04	$0.04	$0.044
69. Screened gravel, l.in.—555 cu.yd.	2.50	2.75	2.75
70. Concrete curbing—35,200 lin.ft.	.70	.90	1.10
71. Catch basins, manholes, type A—3, each.	100.00	100.00	100.00
72. Catch basins, manholes, type B—8, each.	225.00	225.00	225.00
73. Change manhole elevations—38, each	10.00	10.00	10.00
74. Concrete sidewalk, 2 course—5,280 sq.yd.	1.50	1.50	1.60
75. Timber, lumber—1 M.B.M.	80.00	100.00	100.00
76. Relay old pipe—200 lin.ft.	.40	.40	.40
77. Cinders, l.m.—40 cu.yd.	1.20	1.32	1.30
78. C.I. water pipe, 6 in.—396 lin.ft.	1.80	1.90	1.70
79. C. I. water pipe, 8 in.—3,600 lin.ft.	2.00	2.20	2.00
80. C. I. water pipe, 12 in.—550 lin.ft.	3.50	3.80	3.50
81. C. I. water pipe, 20 in.—3,024 lin.ft.	6.50	7.00	7.00
82. Hydrant assembly—24, each.	100.00	100.00	90.00
83. Bell end gate valve, box, 6 in.—4, each.	120.00	120.00	110.00
84. Bell end gate valve, box, 8 in.—14, each.	135.00	135.00	120.00
85. Bell end gate valve, box, 12 in.—6, each.	170.00	170.00	160.00
86. Bell end gate, valve, box, 20 in.—4, each.	300.00	300.00	275.00
87. Blow off manhole—3, each.	190.00	190.00	175.00
88. W. I. pipe, 1¼ in.—300 lin.ft.	.55	.55	.50
89. Lead pipe, 1¼ in.—730 lin.ft.	1.00	1.00	.90
90. Street washer assembly—16, each.	46.00	46.00	.45
91. Steel water pipe, 8 in.—480 lin.ft.	4.00	4.00	4.00
92. Timber guide rail, type A—5,400 lin.ft.	1.25	1.65	1.60
93. Timber guide rail, type B—1,090 lin.ft.	2.40	2.50	2.50
94. Reset timber guide rail—100 lin.ft.	.50	.50	.40
95. Col. cem. conc. pavt. opt. 8-9 in.—59,400 sq.yd.	2.65	2.60	3.13
96. Col. cem. conc. pavt. opt. 8-9 in.—800 sq.yd.	2.85	2.80	3.40
97. Col. cem. conc. pavt. 12 in. reinf.—690 sq.yd.	4.00	3.70	5.00
98. Bit. mac. sidewalk—400 sq.yd.	.90	.90	.95
99. Bluestone flagging—100 sq.yd.	6.00	6.00	6.60
100. Membr. waterproofing, PC—870 sq.yd.	2.00	1.75	2.00
101. Maintain 2-way traffic—total	3,000	3,300	3,300
102. Move, reset monument—total	6,000	6,600	6,600
103. Electrical equipment—total	2,250	2,475	2,400
104. Fire alarm cable, conductors—4,600 lin.ft.	.25	.20	.27
105. Fire alarm cable, 12 conductors—900 lin.ft.	.29	.24	.31
106. Metal railing—70 lin.ft.	12.00	12.00	7.00
107. Grout rock seams—500 cu.ft.	1.00	1.00	1.10
108. Weep holes, rock cuts—300 lin.ft.	.50	.50	.55
109. Emulsified carbon black—87,000 lb.	.08	.08	.07

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